



Insect Pests of Grain in Alberta



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UNIVERSITY OF ALBERTA
FACULTY OF AGRICULTURE

INSECT PESTS OF GRAIN IN ALBERTA

BY

E. H. STRICKLAND

Professor Emeritus of Entomology

1955 REVISION

BY

B. HOCKING

Professor of Entomology



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DEPARTMENT OF EXTENSION, UNIVERSITY OF ALBERTA
Edmonton, Alberta, Canada



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Insect Pests of Grain in Alberta

INTRODUCTORY

Farmers in Alberta are fortunate in that they have to contend with comparatively few insect pests in grain fields. Several of those that do occur in this province are, however, liable to be extremely destructive from time to time. In this group are the grasshoppers and cutworms. Others such as wireworms and wheat stem sawflies cause appreciable losses every year in those districts in which they are well established.

With the knowledge we have at the present time we are unable to gain complete control over any of these pests. The habits of all of them are, however, sufficiently well understood for all farmers to be able to reduce the damage that they would otherwise do by applying the advice that is given in the following pages. This advice is, to a large extent, the outcome of our own experience, though much of it has been obtained from publications of other workers, particularly those of members of the Entomology Division, Dominion Department of Agriculture, situated in the prairie provinces.

References to more complete information are given at the end of each discussion. The majority of publications can be obtained, free of charge, by writing to the institution which issued them. The publications of the Dominion Division of Entomology can be obtained direct from Ottawa, or from the Entomological Laboratory at Lethbridge.

RECOGNITION OF INSECTS IN GRAIN FIELDS

In order that a farmer may select the most suitable method for avoiding or for reducing insect damage, it is necessary for him to identify the insect that is causing it. In many instances he is more liable to notice the damage to his crops than he is to observe the insect that is responsible for it. We have, therefore, prepared the following table to assist in the identification of the culprit from the appearance of the damaged plants themselves.

Identification from damage.

1. Plants fail to appear above ground.

Dig up and examine a number of grains.

a. Grains complete; but have failed to germinate. Not insect damage. May be due to poor seed, to over treatment with formalin, etc., or to the soil being too dry or cold.

b. Contents of grain are eaten out. Large wireworms (p. 28)

- c. Embryos have disappeared. *Small Wireworms* (p. 28).
- d. Grain shrunk. White maggots, resembling those which attack cabbage roots, found in or near them. *Seed-corn Maggots* (p. 50).

2. Plants above ground, but not yet headed out.

- a. Dead plants projecting from soil, blades tightly rolled up and dry. *Wireworms* (p. 28).
- b. Plants, for greater part, cut off at ground level and lying on surface of the soil. *Caterworms* (p. 37).
- c. Central shoot of plant turns yellow, later becomes tightly rolled up and dry. *Wireworms* (p. 28).
- d. Young wheat plants are stunted. Older blades have a bluish tinge and are unusually broad, central shoot withered or missing. *First generation Hessian Fly* (p. 55), or *Wheat Shoot Miner* (p. 50).
- e. Blades yellow or turning brown at the tip, with reddish spots on the upper half. *False Chinch Bugs* (p. 24).
- f. Blades irregularly notched along their edges or entirely eaten. Probably *Grasshoppers* (p. 14), sometimes *Caterworms* (p. 37).
- g. Late seeded cover crops, heavily infested with orange or greenish plant-lice. May turn yellow, then brown and shrivelled, before dying. *Grain Aphid* (p. 25).
- h. Blue-green plant-lice inside rolled up leaves, turning yellow and dying. *Corn leaf aphid*. (p. 27).

3. Heads formed but grain not ripening.

- a. Wheat straw bent over near base and head again turning upwards so that each straw is an N shape. Not insect damage. Probably due to very rapid growth followed by heavy winds.
- b. Wheat, barley or rye straws bend over at 2nd or 3rd node but head does not turn upwards; it is usually prevented from reaching the ground by the blades of neighbouring plants. *Second generation Hessian Fly* (p. 55).
- c. Scattered heads of wheat throughout field have turned white, remainder of plant apparently healthy. Pull out head, with straw, from leaf sheath. If the straw breaks off straight across at the point where it turns white this is not insect damage. If the straw is irregularly chewed just above the top node, *Wheat stem Maggot* (p. 58).
- d. Heads covered with greenish or orange coloured plant-lice. Most common on oats. *Grain Aphid* (p. 25).
- e. Leaves rolled, blue-green plant-lice inside and on heads. *Corn leaf aphid* (p. 27).
- f. Small areas of wheat plants in an otherwise healthy field are seriously stunted and have unusually wide blades. The heads are very short and wide and are infested with a greenish aphid. *Western Wheat Aphid*. (p. 36).
- g. Many flowers at base of heads are "blind," i.e., no grain formed, and turn white prematurely. Most common on oats and barley. *Grain Thrips* (p. 22).

4. Heads ripening or fully ripe.

- a. Wheat stems cut from plants close to ground. *Wheat Stem Sawfly* (p. 41).
- b. Wheat heads cut from plants and fall to ground. *Grasshoppers* (p. 14).
- c. Wheat, barley or rye straws bent over at 2nd or 3rd node from the ground and lying against neighbouring plants or on the ground. This superficially resembles rather light hail damage. *Second generation Hessian fly* (p. 55).

- d. Oats. Individual oats cut from heads and scattered on ground. Grasshoppers (p.14).
- e. Rye. Exposed half of grain eaten. Grasshoppers (p.14).
- f. A few nearly mature grains of wheat have had their contents eaten out; little but the bran remains. Wheat-head Armyworm (p.32).
- g. Wheat heads, and more rarely barley heads, may be a little pale in colour, more often appear to be quite normal but, on close examination, are found to contain little or no grain. "Tap's" Grain Bug (p.23).
- h. Stems with grey blisters which somewhat resemble an early stage of rust. False Chinch Bug (p.24).
- i. Small lace-like cocoons, containing a brown-striped caterpillar, or a small white chrysalis, fastened to heads of wheat. Diamond Backed Moth (p.54).

Identification from specimens.

1. More or less worm-like insects.

May or may not have legs. Found upon or below the surface of the soil.

- a. Cutworms and Armyworms, i.e. smooth skinned, stout caterpillars, up to about $1\frac{1}{2}$ " long. Usually found below ground by day. A few species, however, spend most of their time above ground and may climb vegetation.

(1). General color, light grey, with few body markings.

- i. Head straw-yellow with a blackish Λ or X on the front of it. Never seen before about the middle of May, when they are less than $\frac{1}{4}$ " long. Full-grown and about $1\frac{1}{2}$ " long by middle of June. Pale Western Cutworm (p.44).

- ii. Head bright orange-red, with no markings on it. Body shining and semi-transparent, with a dark internal stripe along its upper side. Seen as soon as the frost is out of the ground when they may be nearly $1\frac{1}{4}$ " long. Glossy Cutworm (p.51).

- iii. Head mottled brown. Body with a number of small black spots. Seen as soon as the frost is out of the ground, when they may be nearly $1\frac{1}{4}$ " long. Early Cutworm (p.51).

(2). General colour dark green or reddish.

- i. With a distinct brick-red band along the entire length of the body. Sides of body may be dark green or creamy yellow. Not seen before about the middle of May, when they are less than $\frac{1}{4}$ " long. Full-grown and about $1\frac{1}{2}$ " long by middle of June. Red-backed Cutworm (p.47).

- ii. Usually dark olive-green all over, sometimes with two rows of poorly defined creamy spots, or with a dull yellowish brown band, along the top of the body. Seen as soon as the frost is out of the ground, when they are $\frac{1}{4}$ " to 1 " long. Full-grown and about $1\frac{1}{2}$ " long by the end of May. Army Cutworm (p.48).

(3). General colour yellowish with broad brown stripes along the body. May be found on heads of maturing wheat. Full-grown and about $1\frac{1}{4}$ " long near the end of July. Wheat-head Armyworm (p.32).

- b. Slender green-and-black caterpillars, up to 1 " long. May crawl in dense armies through grain fields feeding only on weeds. Beet Webworms (p.53).

- c. Dull brown cutworm-like insects with wrinkled skins and apparently no heads or legs. Not very active.

(1) Never more than $\frac{1}{4}$ " long. Body covered with fleshy spurs somewhat resembling rose thorns. Sometimes very numerous in the spring. March flies (p.66).

(2) Up to $1\frac{1}{4}$ " long. No fleshy spurs on body. Leather jackets (p.66).

- d. Orange coloured shining grubs with very tough skins. Up to 1" in length. Always found below ground.
 - (1) Not very active when disturbed. Usually rather flattened and with two blunt claws at the hind end of the body. Wireworms (p. 28).
 - (2) Extremely active when disturbed. Body cylindrical and always pointed at hind end. False Wireworms (p. 28).
- e. White "worms" which are very slender, with no legs; up to 1" long; extremely active when disturbed. These are the larvae of a fly. They feed on other insects. Beneficial. *Therevid* larvae.
- f. Pale grubs with brown heads and well developed legs. Do not curl up when disturbed; may run rapidly. Usually about $\frac{1}{2}$ " long. These feed mainly on very young wireworms, cutworms and grasshopper eggs. Beneficial. Ground beetle larvae.
- g. Black grubs, up to 1" long. Well developed legs, run rapidly. Feed on cutworms and wireworms. Very beneficial. *Cutworm lions* (p. 46).
- h. Greyish white grubs, about $\frac{1}{4}$ " long by the middle of June, body always bent in C shape so that its hind end lies under the head. Look somewhat like small cutworms. Quite harmless, often numerous in fields which have been manured. Dung-beetle larvae.

2. Moths.

- a. Brown-black or grey moths, about 1" long, which are very common in houses throughout the summer. Most of these are Army cutworm moths (p. 48). Glossy cutworm moths (p. 31), or the moths of other cutworms which are not very injurious to grain. The greenish moths of the Pale Western cutworm (p. 46), and the reddish or yellowish moths of the Red-backed cutworm (p. 47) do not often enter houses. They may be very abundant in the fields, but do not attract much attention since they fly chiefly after dark.
- b. Small light grey moths, about $\frac{3}{4}$ " long, often fly in clouds around flowering weeds and around lights at night. Best webworm moths (p. 37).

3. Beetles.

- a. Black or brown beetles which run very quickly, and hide under stones, etc. Nearly all feed on other insects and are beneficial. Ground beetles. (p. 39).
- b. Small black beetles, about $\frac{1}{4}$ " long, with a distinct furrow across the middle of the back. If placed upside-down on a smooth surface they jump into the air with an audible click. No other beetle does this. Wireworm beetles (p. 28).
- c. Large black beetles, sometimes with small metallic red or green spots on wing covers, about 1" long. Long legs, run very quickly. *Pierry Antlers* (p. 35).
- d. Large black beetles, up to 1" long. Walk very clumsily, and stand on their heads if mildly alarmed. Often seen in gopher holes. False wireworm beetles (p. 35).

4. Grasshoppers and their relatives.

There are about 10 different kinds of grasshoppers in Alberta. Of these not more than three are liable to be very injurious to grain fields.

- a. Small wingless hoppers, only partly grown. (All injurious grasshoppers are in this stage of development only late in May and throughout June).
 - (1). Mainly black, but with strongly contrasting white marks on body

and legs. Usually found in sod around grain fields or in small pastures. *Roadside grasshopper* (p. 17)

- (2) Very small, dull brown, with well-marked square light and dark areas along the top of the jumping hind legs. Young *Lesser Migratory Grasshopper* (p. 18)
- (3) Half-grown hoppers. Bright yellow-and-black, with fine black lines on yellow wing-cases. Most abundant in recently deserted fields, or in and around stubble with a dense growth of weeds. Partly developed *Lesser Migratory Grasshopper* (p. 18)
- (4) Bright green. Most abundant in fall rye or weedy areas. *Two-striped Grasshopper* (p. 18)
- (5) Light grey, more slender than usual. Often found in sod at a distance from cultivated land. These are harmless to grain.

b. Full-grown grasshoppers and crickets

- (1) Coloured hind-wings, red-and-black, or yellow-and-black. All of these are practically harmless to grain.
- (2) Transparent hind wings.
 - i. 1 1/4" long. Mottled brown or yellow, with large dark marks on front wings, and two rather faint yellowish stripes forming a long V on the crossed front wings. Eyes round. *Roadside Grasshopper* (p. 17)
 - ii. 1-1 1/4" long. Nearly uniform brown without very definite marks on front wings. Eyes about twice as long as wide. *Lesser Migratory Grasshopper* (p. 18)
 - iii. 1 1/2-2" long. Dull greenish yellow. Front wings about the same colour as body with the exception of two conspicuous straw-yellow stripes forming a long V forwards along the thorax and head. Eyes about twice as long as wide. *Two-striped Grasshopper* (p. 18)
- (3) Wingless. About 1 1/2-2" long, much stouter than an ordinary grasshopper. Female with a sword-like ovipositor that is nearly as long as the rest of the body. Most abundant in the foothills. *Mormon Cricket* (p. 20)
- (4) Black crickets, about 1" long, incapable of flight, but with short wings. *Field Cricket* (p. 20)

5. Bugs.

(Flattened, somewhat beetle-like insects but with softer wing covers and with a sucking mouth, appearing like a long tube which is pressed close to the under side of the body.)

- a. Stout green bugs, about 1/2" long. *"Jay's" Green Bugs* (p. 23)
- b. Smaller, softer, black or black-and-yellow bugs, without wings. *Immature Green Bugs*.
- c. Rather soft. Light brown or greenish bugs, about 1/2" long. Extremely active and fly freely. These are harmless in grain fields, where they feed only on weeds. Very injurious to alfalfa seed production. *Lygus bugs*.
- d. Very small bugs, 3/16" long. Dark greyish-brown. *False Chinch Bugs* (p. 24)

6. Flying insects other than moths, beetles or grasshoppers.

- a. Small black-and-yellow, slender wasp-like insects, about 1/2" long. Usually rest head downwards on wheat stems. Seen only in May and June. *Wheat Stem Sawflies* (p. 43)
- b. Rather large but slender black wasps with black wings, about 1" long. Very active, run on ground or make short flights. Capture, and

eventually destroy half to full-grown cutworms. Beneficial. Solitary wasps (p. 45)

7 Eggs, pupae or cocoons turned up with the plough.

- a. Covered with or entirely composed of, earth.
 - (1) Hard, less than an inch long, somewhat resemble gopher droppings. When broken open seen to contain yellow eggs. Grasshopper eggs (p. 34)
 - (2) Hard, about 1" long, roughly oval, composed entirely of earth. Usually found with one end open and empty. Cutworm pupation cell (p. 39)
 - (3) Soft, about 1" long, narrow, elongate somewhat resemble pieces of decaying sticks. When pulled apart seen to be composed of silk. May contain small caterpillar or pupa. Beet webworm cocoons (p. 34)
- b. Reddish brown, hard shelled, chrysalis, less than an inch long. Head end ringed and movable. Cutworm pupa (p. 39)
- c. White, delicate skinned pupa, with very soft wings and legs all pointing backwards and ying on the underside of the body. Beetle pupa probably of Ground Beetle *Wierworm* or False *Wierworm*.
- d. Hard-shelled, dark-brown oval structure with a perfectly smooth surface. Usually open at one end and empty.
 - (1) About $\frac{1}{4}$ " long. Similar objects abundant in dead animals. Pupa of a Fly. Probably a cutworm parasite.
 - (2) About 1" long, appears to be composed of many very thin sheets of a material that has metallic reflections. Cocoon of Solitary Wasp (p. 45)
- e. Yellow eggs resembling small grains of wheat. Most abundant just below soil surface in soil. Seen only in early spring. Eggs of Roadside Grasshopper (p. 14) which have swollen during the winter and have broken from the earth covered egg mass in which they were laid.

RELATION BETWEEN THE LIFE-HISTORY OF INSECTS AND CONTROL MEASURES

Nearly all insects change in their appearance and often in their feeding habits to a greater or lesser extent, between the time when they hatch in a wingless condition from their eggs and when they are fully developed flying insects.

A recently hatched hopper is, however, sufficiently similar in appearance to a mature flying grasshopper for anyone to recognize it as being the same insect. Whenever the change in appearance is no greater than this, the insect can be active throughout its life and its feeding habits do not change from the time it hatches until it dies. For this reason we can usually employ the same control measures for these insects throughout their lives.

A caterpillar or cutworm, on the other hand, is so totally different from the moth into which it will develop that no one who did not already know it, could tell that it really is a young moth. So great is the difference in structure that the insect cannot change from the one to the other without becoming inactive, as a pupa,

while the change is taking place. Not only does the structure change completely, but so do the feeding habits. The cutworm eats solid food, such as leaves, while the moth can suck up fluids only and feeds on nectar from flowers. We cannot, therefore, employ the same control methods throughout the life of the insect. In certain cases it is much easier to control such insects in a stage in which they may be doing us no damage whatever than it is in the stage in which they are serious pests.

CONTROL MEASURES WHICH CAN BE EMPLOYED BY GRAIN PRODUCERS

Use of Poisons.

Until recently it has not been practical to employ poisonous sprays or dusts for the control of insect pests in grain fields. In recent years, however, several new poisons have been developed which appear to be very effective and to be sufficiently inexpensive to justify their employment for this purpose. Chemical methods, however, are supplementary to and not substitutes for good farming practices.

Cultural Practices.

We would stress the fact that all of our serious grain pests are native to Alberta. Before the advent of agriculture, nearly all of them were kept to small numbers by natural means. Often the feature of an agricultural process which has permitted the serious multiplication of an insect species is incidental and its elimination will permit nature to control the numbers of an insect once more.

Since the majority of grain pests live for at least a part of their lives, below ground, it is often possible to reduce their numbers or the damage that they can do, by modifying cultural practices. Several such modifications will be discussed in this bulletin. When they can be employed without seriously upsetting the routine of the year or resulting in danger of soil drifting, loss of moisture, etc., they should always receive very careful attention. These modifications entail no additional expense and may greatly reduce losses from insect pests.

It should be borne in mind also that vigorous plants, as a rule, suffer less from insect damage than do those which are making a poor growth. For this reason, rapid growth should be encouraged at all times. In the case of certain insects, such as wireworms, the application of fertilizers, particularly phosphates, in order to counteract soil deficiencies in these materials may so stimulate the plants that they have a marked effect in reducing insect damage.

The principle of rotations as applied to insect pests, is to avoid growing the same crop year after year in the same field since this

gives the insects that feed upon it an opportunity for an abnormal increase in numbers.

Under existing conditions there is little scope for practising rotations on grain-producing farms. In districts which are infested with the wheat stem sawfly it will, however, be seen that alternating wheat with some other non-susceptible crop or with summerfallow, is practically a necessity during years of sawfly abundance.

CULTURAL PROGRAMME ADAPTED TO THE REDUCTION OF MOST GRAIN PESTS

Shallow Fall Cultivation of Stubble.

It is obvious that, on the open prairie and hardly to a lesser extent elsewhere, the only places where the majority of grain infesting insects can pass the winter are either on the surface of the soil, whether protected by trash or otherwise, or below ground. Farmers, therefore, have an excellent opportunity to reduce insect numbers by disturbing the top few inches of the soil before freeze-up, since by so doing they can greatly increase the winter mortality of those which normally hibernate here in a resting stage.

Shallow fall cultivation of stubble, in which an effort is made to bring all of the stubs to the surface and to leave them lying there, is the safest method for reducing many pests, such as grasshoppers (egg destruction), sawflies (larval destruction), webworms and shoot maggots (pupal destruction). For many pests, the earlier the cultivation can be accomplished after harvest the heavier will be the mortality.

Deep fall ploughing, though it may bury the eggs of cutworms, etc., deeply in the soil, is not very valuable. It tends to give certain pests added protection from winter temperatures and it may increase their survival. It is doubtful whether deep spring ploughing has any effect in the control of insect pests. Even when it is followed by a packer, the soil will rarely be sufficiently compressed to imprison any insects which are turned under.

Summerfallowing.

A perfectly clean summerfallow, particularly from mid-June to mid-July, will destroy many insects which would have matured on volunteer grain or weeds. Until early in June, this volunteer growth may serve as a rather useful trap-crop in attracting insects, such as sawflies and house flies, for egg laying. These can then be destroyed with the growth by late June summerfallowing. It is recommended that, during this period, repeated shallow cultivation replace any deep ploughing. Such cultivation will not loosen the subsoil and so will discourage deep egg-laying by wire-worm beetles. It will encourage the germination of shallowly placed

weed seeds, will destroy any resulting growth before more seeds can be produced and avoid deeply burying resistant weed seeds which would cause trouble in future years.

If deeper ploughing is necessary it is suggested that this be done in so far as possible during the latter half of July. This will

1. Destroy nearly all of the pupating wireworms in the field.
2. Assure that there will be no vegetation of a sufficient size to attract red-backed cutworm moths for egg-laying during August.
3. Give time for a crust to form on the surface before pale western cutworm moths begin egg-laying.
4. Assure that no grasshoppers will lay their eggs in the field.
5. Destroy the majority of any cutworm pupae which may be in the field.
6. In all probability, prevent any annual weeds maturing and producing seed before freeze-up.

If it is not necessary to plough at this time, it is suggested that the final cultivation during the latter half of July be about an inch deeper than that employed earlier, in order to destroy wireworm pupae.

GRASSHOPPERS AND THEIR RELATIVES

GRASSHOPPERS

Most species of grasshoppers in Alberta are not a menace to grain producers since they feed almost exclusively on native grasses and weeds. Several of them are more beneficial than otherwise. They harbour important parasites of the injurious species at seasons of the year when the latter are not available for them. There are, however, three species that are liable to be extremely destructive to grain when they are present in abnormally large numbers. Outbreaks of these grasshoppers as a rule take a number of years to develop, and they could often be checked from the start if everyone in the threatened territory noticed the gradual increase in numbers and immediately took the proper steps to reduce them.

For this reason, and also in order that money and labour will not be wasted in an attempt to reduce the numbers of harmless species, it is very important that everyone is able to recognize the injurious grasshoppers in all stages of their development.

Habits of Injurious Grasshoppers.

All injurious grasshoppers lay their eggs in the soil. The females dig holes in the ground and fill them with 25 to about 50 eggs. These are surrounded with a gummy substance that hardens and sticks the eggs together. Though the eggs are all laid in the fall they do not hatch until about the end of the following May.

The small wingless 'hoppers feed continually on vegetation and gradually increase in size until early in July, when most of them are full-grown and are able to fly. They then become much scattered throughout grain fields that may have been free from 'hoppers earlier in the year.

Hoppers grow by a process of moulting; they shed their skins periodically. Whenever 'hoppers are numerous these empty skins will be found in large numbers. They must not be confused with dead 'hoppers.

The flying grasshoppers continue to feed. They begin to lay their eggs about the end of July and continue to do so until they are killed by frosts in the fall.

Causes of Grasshopper Outbreaks.

A variety of climatic conditions produce grasshopper outbreaks. Generally speaking a succession of dry hot years with open falls

results in an increase in the number of grasshoppers. Timely rains, with cold, overcast weather in the latter part of May, may kill a great many of the young 'hoppers, but a wet season cannot be relied upon to terminate an outbreak.

Termination of Outbreaks.

One of the most important factors that terminate outbreaks of grasshoppers is the gradual increase of their natural enemies—other insects that are parasitic upon them. In the early stages of an outbreak the proportion of parasites is very small. It usually takes them several years in which to re-establish their numbers at the expense of the grasshoppers. If during these years, we can destroy a large number of the grasshoppers with bats or by any other means, we hold their numbers more closely to the proper proportion with the parasites and hasten the year in which the latter will again be able to keep them under control.

Control Measures.

Cultural.

No eggs are ever laid in well-worked summerfallow land. Such fields will be free from 'hoppers in the early spring, but they may later be infested by migrations from elsewhere.

Since many eggs (lesser migratory and two striped grasshoppers) are laid in weedy stubble, cultivate shallowly every field in which grasshoppers are numerous immediately after harvest. The "trash mulch" thus produced reduces soil drifting, no more eggs will be laid and over half of those already laid will be destroyed. Fields so treated will be practically free from grasshoppers (and wheat stem sawfly infestation will be reduced) in the following spring.

Use of Fire.

Burn over dead vegetation in which 'hoppers are numerous in the spring. Be sure that the 'hoppers have all hatched before so doing. This is the cheapest, and most thorough way to kill grasshoppers and it does so before they have done any damage. Farmers will do themselves more good by burning over badly infested vacant land two or three miles from their own fields than they will by scattering bait in lightly infested crops. Remember that every grasshopper in vacant land will fly to neighbouring grain fields later in the season.

Note, particularly, recommendations given in discussion of each species, for killing young 'hoppers with fire. Poisons should be employed only where it has been found to be unpractical to destroy the 'hoppers with cultural methods or by the use of fire.

POISONS

Poisons for grasshopper control are best applied in the form of sprays where there is much vegetation especially if this is being fed on by grasshoppers. Where vegetation is deficient baits should be used. When in doubt on this score, use baits for young nymphs, sprays for adults. Sprays should never be used on vegetation which may be fed to livestock or used as human food unless an interval of at least three weeks can be allowed. Any spray equipment of sufficient capacity for the area to be covered is satisfactory. Spray when the temperature is moderate and the wind light.

The following quantities of actual poison are required

	Per 100 lbs dry bait	Per acre sprayed
White arsenic	1 lb.	—
Chlordane	1 lb.	$\frac{1}{2}$ - $\frac{3}{4}$ lb.
Toxaphene	1 lb.	1 - $1\frac{1}{2}$ lb.
Lindane	1 oz.	1 - $1\frac{1}{2}$ oz.
Aldrin	$1\frac{1}{2}$ - 2 oz.	$1\frac{1}{2}$ - 2 oz.

The best bait base is a mixture of equal parts of bran and sawdust; the poison is best mixed with water at the rate of about 10 gallons to 100 lbs. of bait, and the diluted poison then intimately mixed with the bait base. The maximum application rate is 20 lbs. wet bait per acre. If a 25 per cent wettable powder is being used, the weight of this required will, of course, be four times that given above.

Never scatter bait anywhere where grasshoppers are not numerous, as it dries it loses its attraction for them.

Never apply bait on a cool, windy, or rainy day. At the time when the bait is spread the air temperature must be at least 68°F and the best results will be obtained if there are prospects that the temperature will continue to rise. If however the temperature of the surface of the soil is nearly 100°F grasshoppers feed very little and the bait will dry out so rapidly that few of them may eat any of it before it ceases to be attractive to them.

When temperature conditions are satisfactory, broadcast bait between the hours of 7 and 10 a.m. At this time grasshoppers are doing most of their feeding, and the bait remains moist for the longest time.

Throw the bait as far from you as you can. One poisoned flake will kill several small grasshoppers. The more scattered these flakes are the better will be the killing.

In certain seasons, practically all of the grasshoppers in any one field will hatch within two or three days and it will be noticed that they are all of about the same size. When this is the case, one good application of poison should effect a satisfactory control.

Unfortunately in some years, hatching is very irregular and it may extend over several weeks. In such years, grasshoppers of several sizes will be found in the field. It may be wise to delay poisoning until very small ones are no longer seen. This will reduce the danger of having to repeat the poisoning.

Properly scattered bait is absolutely harmless to stock. When stock are killed it is always due to improper handling of bait. Never leave bait in bulk where stock can get at it. Don't use bags for feed if they have contained bait and do not leave them where stock can lick them. If baiting pastures, see that the stock are well supplied with salt, and be sure you scatter the bait thoroughly.

ROADSIDE GRASSHOPPER (*Camnula pellucida*).



FIG. 1—Roadside Grasshopper —A. Egg masses, one broken open to show eggs. B. Young 'hopper, soon after hatching (much enlarged). C. Full-grown grasshopper laying eggs. All except B are natural size.

Distribution.

Entire province Most abundant in southern half and in the
Peace River district Usually found in largest numbers where soil
is rather heavy

Life-history.

The eggs are nearly always laid in unbroken sod. The females collect into well-defined breeding areas, in which practically all of them lay their eggs. During outbreaks eggs may be very abundant in the sod around grain fields. Even here they will be found only in well defined breeding areas, possibly of only a few rods in length.

When the small black-and-white 'hoppers hatch they may at once spread into the edges of the grain field by day, but for about the first two weeks of their life they return at night to the sod where they hatched. A little later they spread throughout the entire fields. When half-grown they are almost completely black, and are more "chunky" in build than are most grasshoppers.

Special control measures.**Burning over sod.**

Since, for about two weeks at the end of May or early in June, roadside 'hoppers collect in the sod around fields every night, nearly all of them can be killed by scattering a little straw here and burning it off after dark. The only precaution to take is to be sure that all of the 'hoppers have hatched. Fire will not destroy the buried eggs. Nearly all 'hoppers will have hatched within three days of the time that they first were seen.

Poisons.

The best results will be obtained by using baits or sprays early in the season while the 'hoppers are still crowded together in the breeding areas. In mid-summer when they are already scattered, baiting is of far less value. In late summer, however, when the grasshoppers are again collecting into their breeding areas, these areas can be baited with excellent results.

LESSER MIGRATORY GRASSHOPPER (*Melanoplus mexicanus*)

TWO-STRIPED GRASSHOPPER (*Melanoplus bivittatus*)



FIG. 2.—A. Lesser Migratory Grasshopper; B. Two-striped Grasshopper.
Both natural size.

The habits of these two grasshoppers are sufficiently similar that, for all practical purposes, the control measures for them are the same.

Distribution.

Entire province, but most abundant in districts in which the soil is light.

Life-history

Eggs usually laid in deserted fields and in weedy crops. Since these eggs are scattered throughout such fields, the control of these species is far more difficult than is that of the roadside grasshopper.

Special control measures.**Burning weeds.**

When a field in which there is a dense growth of weeds, such as Russian thistle or mustard, is found to be heavily infested with

Hoppers, it should be burned over shortly after all of the hoppers have hatched. This can often be accomplished with the aid of harrows when a good burn cannot otherwise be obtained. The hotter the day, as a general rule, the more complete will be the burn. For these hoppers there is no advantage in burning at night.

In this connection it should be remembered that it is in such fields that the increase in the number of grasshoppers takes place. They are the source of infestation of grain fields later in the season, and it is far more difficult to kill grasshoppers in grain fields with bait than it is to destroy them with fire among weeds.

Summerfallowing.

Land that is being summerfallowed, and which is found to be heavily infested with hoppers should be ploughed from the outside towards the centre. This crowds the hoppers together onto the unploughed portion, which should be treated with bait and left for two days before ploughing is completed. A modification of this is to plough the field in "strips" after ploughing a barrier of about a rod wide right round the field, and to bait the unploughed centre of each strip two days before turning it under. When this is not done all of the hoppers that were in the field will be driven into neighbouring grain.

Poisons.

Sprays can be used or bait can be broadcast in uncultivated fields which cannot be burned over in early summer. This will destroy a large percentage of the hoppers.

When flying grasshoppers have entered and scattered throughout a grain field, bait should be broadcast in strips, about two rods apart, throughout the field. Since flying grasshoppers are very active, most of them will find and feed on the bait before it has dried out. This reduces the cost and labour of baiting by about half.

For further information see:

- Putnam, L. G. "Sprays and dusts for grasshopper control." Division of Entomology Processed publication 73, 1949.
Putnam, L. G. "Protecting cover crops and fall sown grains from grasshopper damage in the prairie provinces." Division of Entomology Processed publication 126, 1963.
Handford, R. H. and Putnam, L. G. "Grasshopper control." Division of Entomology Processed publication 115, 1951.

MORMON CRICKET (*Anabrus simplex*).

FIG. 3—A. Female Mormon Cricket. (The male has no ovipositor, and is smaller), B. Female Field Cricket. Both natural size.

Distribution.

This large wingless insect does not often attract attention in Alberta, though it is liable to occur in destructive numbers in the southwest portion of our province in seasons which have been favourable to its increase.

Life-history.

The eggs, unlike those of grasshoppers, are laid singly in the soil. Early in the summer the young crickets eat plants completely. Later, when the heads are formed, they may climb up to the heads and eat out the developing grain. They do this most freely in the evening. These crickets, however, feed freely on grasshoppers and, when they are not very abundant, may be more beneficial than otherwise.

Control.

When this is necessary, the poisons used against grasshoppers are effective.

FIELD CRICKET (*Gryllus assimilis*).**Distribution.**

Throughout the province.

Life-history.

The eggs are laid in the soil singly. They do not hatch till about the beginning of July, and, since the young crickets are unable to climb plants, they do no appreciable damage to growing grain. They are mature at about harvest time. During the hottest part of the day they inhabit cracks in the soil and come out to feed only at night or on cloudy days. Unfortunately they are very fond of eating binder-twine, and, if sheaves are left lying for some time in fields in which crickets are numerous, many of them may be cut.

Control.

Twine that has been treated by the manufacturers to protect it from crickets or field mice will not be damaged. Untreated twine can be protected by soaking for half-an-hour in a solution of 1 lb. of bluestone in 6 gals. of water. Thoroughly dry and pound the balls with a stick to loosen them up and to avoid knottier trouble.

In a field in which crickets are seen to be numerous, stack as soon after cutting as possible.

THRIPS, BUGS AND PLANT LICE (Aphids)

GRAIN THRIPS (*Anaphothrips orietalis*).

Distribution.

Entire province.

Life-history and habits.

Thrips are minute, slender, black or brown insects about $\frac{1}{16}$ " long. They are so small that they are rarely seen. If a dandelion flower be tapped on the hand it is probable that a few of them, which are thus dislodged, will be seen running across the hand. They are quite strong fliers.

Grain thrips pass the winter in stubble, in grass along the head lands and among weeds. Early in the spring they lay minute eggs in slits cut in the leaves of grasses. Small wingless thrips hatch from these and feed on the young growth of grass. By about the end of June these thrips are full-grown and have developed wings. The females leave the grass and many fly to grain. Here also, they lay eggs in small slits cut in the upper blades.

The young thrips which hatch from them enter the "boot" and feed on the developing grain flowers. They will not feed on any flowers that are already exposed at this time, but only on those that are still protected by the sheath.

Damage to grain.

Oats suffer more than do other grain crops. "Blind" oats, i.e. oat flowers that turn white prematurely and contain no seed, have various causes. When they are scattered throughout the heads of oats they are not due to insect damage. Blind oats which are confined to the base of the head are, however, often caused by thrips.

In order to make certain whether thrips are present in sufficient numbers to have caused the trouble, gather a few of the upper blades from injured plants. Hold them to the light. Small translucent areas, like pin-points, indicate places where thrips have laid their eggs. Tear open the upper leaf-sheath to expose the flowering stem down to the top node. If thrips are abundant it is probable that a few dead specimens will be found within the sheath.

Control.

Since grain heads that are fully exposed by the end of June are not attacked, only late seeded oats and barley are liable to suffer from thrips injury. Early seeding of rapidly maturing varieties will largely overcome the trouble in badly infested fields.

Fall ploughing or fall stubble burning, with the destruction of rank growth of grass along the headlands, will destroy many of the hibernating thrips. They are active so early in the spring that spring operations are of comparatively little value.

"SAYS" GRAIN BUG (*Chlorochroa* sp.)



FIG. 4—"Says" Grain Bug.—A. Five eggs laid on piece of old stubble, B. Half-grown black and yellow bug, C. Mature bug, which is green, D. False chinch bug. All figures natural size.

Distribution.

At present this bug appears to be confined to the wheat producing belt to the south and east of Calgary. It is most prevalent to the south of the South Saskatchewan River, where appreciable losses have occurred. Specimens have, however, been found as far north as the Yukon.

History in Alberta, and food plants.

From the earliest days of wheat production in Alberta, a few large green bugs have been observed in grain fields. In 1935, they were found in greatly increased numbers in southern Alberta and were causing serious damage to wheat. Since then, this bug has caused appreciable losses annually. It is most destructive to wheat, but will also attack barley, rye and oats.

Life-history and habits.

The life-history of this bug has been studied by Mr. L. A. Jacobson, of the Dominion Entomological Laboratory at Lethbridge. It is as follows:

The large green bugs pass the winter in hiding under rubbish on the ground such as dead weeds or trash mulch, and in tufts of native grass. During this season, many of them turn to a reddish-brown colour. Early in the spring they resume activity and the females lay their eggs chiefly on the underside of the rubbish, where they have passed the winter. The young wingless bugs are largely black, with a few yellow marks, but they gradually assume a green colour as they mature. These feed, at first, on young Russian thistle and other weeds but, when they are about half-grown, they may begin to climb to heads of wheat and to feed there. The mature green bugs feed almost entirely on grain. They fly freely from field to field. There are at least two generations a year.

Damage.

The bugs feed by sucking the contents from the developing grain. This may result in the head turning a rather pale colour before the unaffected heads ripen but, more often, no damage is observed unless the attacked heads be squeezed between the fingers, when they are found to contain little or no grain. Often no damage is suspected until after the grain has been threshed and has been found to yield far less than was anticipated.

Control.

The only control measure which can be recommended at present is "the early spring burning of weeds and rubbish, under which the adults pass the winter". Jacobson also states that "cropping practice, adjusted by dates of seeding, appears to be of no value in controlling losses."

For further information see

Jacobson, L. A., "Say's Grain Bug in Western Canada" *F.C.I.I.*, 267 Division of Entomology, Ottawa, 1940.

FALSE CHINCH BUG (*Nysius ericeae*)**Distribution.**

Entire province. Most prevalent where mustard grows to profusion.

Life-history and habits.

These bugs closely resemble chinch bugs, for which they are sometimes mistaken (See Fig. 4, p. 23). The true chinch bug does not occur in Alberta, and it has a white area over the greater part of the hinder end of the body. The false chinch bug is almost uniformly greyish-brown.

Winter is passed by the full-grown bugs which hide under dead vegetation. In the spring they resume activity and with their hollow needle-like mouths, they suck sap from practically all types of plants. They lay their eggs on the plants on which they are feeding. From these hatch small bugs which are similar in appearance to their parents, though they will remain wingless till they are full-grown. There are several generations in a year.

Damage to grain.

False chinch bugs increase rapidly in numbers in fields that have grown up to mustard and some other weeds. When such fields have been cleaned up and seeded in the spring, the bugs which have passed the winter successfully attack the grain seedlings and suck sap from their blades. Each feeding puncture turns red, and the portion of the leaf beyond it may become a sickly yellow. If mustard seedlings now appear in fairly large numbers, nearly all of the bugs

will leave the wheat and feed on them. In any case, the damage is not severe, though the plants may be set back. Later in the season, when mustard is mature and is dying off, many bugs return to the grain and feed on the flowering stem and on the outside of the leaf-sheaths, causing a blistered, rust-like appearance.

Control.

Keep summerfallow clean. There will then be no weeds on which the bugs can increase in numbers.

Plough in weedy stubble in the fall, or burn off early in the spring. Since the bugs are quite active at the usual time of spring ploughing this will not make a thorough job of burying them though it is preferable to cultivation.

GRAIN APHID (*Macrosiphum granium*)

Distribution.

Entire province. Frequently extremely numerous.

Life-history and habits.

Occasionally the heads of all grain crops are found to be swarming with small wingless orange or green plant-lice or aphids. Scattered among them will be a few individuals that are darker in colour and which possess transparent wings.

It is not known how these plant-lice pass the winter in Alberta. It is probable that they are unable to do so here, and that infestations are the result of a few flying aphids which migrate into the province from farther south early in the summer.

Plant-lice can increase in numbers more rapidly than can any other insect. Generation follows generation rapidly throughout the summer. All remain wingless unless they have become so numerous on a single plant that they are seriously overcrowded. Whenever this occurs a few winged specimens appear. These fly to and infest new plants. They feed by sucking sap from the heads and from the stems of plants.

Damage to grain.

However abundant the plant-lice may be on maturing grain, they do surprisingly little damage. We have seen a field of oats in which the lice were so numerous at harvest-time that the binder was literally gummed up with their crushed bodies. This field yielded 110 bushels per acre. A field of wheat, similarly infested, yielded 34 bushels of No. 1 grain. The chief damage, therefore, is in rendering harvesting operations disagreeable.

Despite this fact, extensive damage was caused to late-seeded cover-crops towards the end of the summer of 1948. This damage appears to have been confined to south-west Alberta. Oats, seeded

in July for pasture crops, were most seriously affected but neither barley nor wheat was immune.

Damage was first apparent as small patches of oats which turned yellow. Within a few days' time these turned brown and died while steadily progressing belts of yellowing spread from them until whole fields were killed out.

In an earlier year, plots of both oats and wheat which were seeded early in August on the University farm at Edmonton became infested almost as soon as they were above ground. By mid-September, many plants were completely covered with aphids. On the night of September 16 a frost killed all of the aphids but it did not affect the plants, which continued to grow for another two weeks. A close examination of them failed to show that the aphids had caused any damage.

Control

Nothing practical can be done to prevent infestations or to reduce the aphids present on grain. We have never known them to occur for two years in succession in the same district.

WESTERN WHEAT APHID (*Brachycolus tribus*)

During the past thirty years this aphid, which severely stunts the growth of winter wheat, has affected this crop in several districts of Montana. The following account of its habits is taken largely from a paper which was published in 1911 by Dr. J. R. Parker of the Experiment Station of that state.

Distribution.

In 1944, it was found that the aphid had invaded Alberta, but was confined to a few fields in the neighbourhood of Cowley, near the Crow's Nest Pass. It does not appear to be spreading from this area.

Life-history and habits.

Eggs are laid in the fall on winter wheat and they hatch in the following April. In common with all plant-lice, the increase in the number of these aphids is very rapid throughout the summer. By mid-June many of the light yellowish-green, wingless or winged, aphids may be found on the wheat plants.

Damage.

Individual plants, or small groups of them, are very stunted in their growth. In early summer the blades are much wider than is normal and many of them may be streaked with white. By the time the heads are fully formed, the flowering stem is less than half its normal length while the head itself is broad and flat and may be

only about three times as long as it is wide. The topmost leaf blades are frequently tightly wrapped around this deformed head, which rarely produces any grain.

Control.

The most important control measure is that of seeding winter wheat only in fields that have been absolutely free from volunteer grain, or grasses, during the preceding summer. Should any field in Alberta appear to be so heavily infested with this aphid in early summer that there is a question as to whether it will produce a crop, it can be ploughed in and seeded to oats, which are entirely immune.

CORN LEAF APHID (*Rhopalosiphum maidis*).

The first record we have of this aphid in Alberta is 1943 when specimens were taken on corn at Lethbridge. In 1948 barley in the University greenhouses was infested.

Distribution.

In 1953 without further warning it was perhaps the most serious agricultural pest in Canada. Several hundred thousand acres of barley were destroyed in the prairie provinces, especially in Saskatchewan. This was almost certainly the result of unusual weather conditions, which may not recur in a generation, bringing winged forms in from the southeast.

Life-history and habits.

The complete life-history of this species is not known. In the southern states it overwinters on barley, it is most unlikely that it can pass the winter here. Barley, corn, and millets are the preferred food plants, in the order given. It is rare on wheat and oats and probably never breeds on plants other than grasses.

Control.

In crops which are heading out and in good condition no control appears to be necessary. Very late crops which are already so badly affected that they show extensive yellowing do not justify control. In intermediate crops Malathion sprays gave excellent results, especially if aerial application is possible so that the crop is not damaged by equipment. The best safeguard is, of course, early seeding.

WIREWORMS AND OTHER LARVAE OF BEETLES

WIREWORMS

Wireworms are the larvae of click-beetles. (See p. 8). Over 30 different kinds of click-beetles have been captured in Alberta. Nothing is known of the habits of the larvae of most of these. Of those that are known, several are certainly harmless to grain since they live only in decaying wood. About ten different kinds of wireworms have been found in grain fields, three or four occasionally in sufficient numbers to cause damage, but only one is a widespread pest of grain crops in Alberta. This is the northern grain wireworm.

A second species, which has no common name and which is very much smaller, is often associated with it in fields in which there is much sod, while a third, which is also very small, is sometimes very destructive in the extreme south of the province.

NORTHERN GRAIN WIREWORM (*Crepidion sordidum* var. *destructor*).



FIG. 5.—Northern grain wireworm. A. Half-grown wireworm attacking grain, B. Full-grown wireworm. (Note the flattened plate with two double claws at the end of the body.) C. Pupa in cavity in the soil, D. Adult click-beetle. Do not confuse with E, a fast-running ground beetle, which feeds on very young wireworms. Ground beetles vary much in shape, but they never have the two backwardly pointing spines, one on each side, near the middle of the body. All figures natural size.

Distribution.

Widespread but not often encountered in destructive numbers except in central Alberta and the Peace River district. Although it is quite common throughout the southern part of the province, it is less abundant there than it is farther north, and is usually associated with other species of wireworms and with false wireworms, with which it is liable to be confused. In those areas of northern Alberta that were originally fairly densely covered with

trees or bushes it rarely occurs in sufficient numbers to cause appreciable damage.

Habits and Life-history.

Beetles.

No beetles other than those of wireworms jump into the air with an audible click if they are placed on their backs on a smooth surface. Although they normally remain inactive in the soil throughout the winter, they are not harmed if they are disturbed by fall ploughing. In the spring, as soon as the soil warms up, they struggle to the surface and on fairly warm days they wander over the fields. Egg laying females never fly. They rarely move very far from the place where they lived as wireworms before laying their eggs, since in their wandering they often retrace their steps.

Late in May and throughout June the females make frequent trips into the soil for the purpose of egg-laying. Depending on the temperature, moisture, and firmness of the soil at this time, they deposit their eggs at any depth from just below the surface to five or six inches deep. About 250 eggs are laid and they hatch in about a month.

Larvae.

Most insects complete their life-cycle in a single year. It is important to remember that this is not so with wireworms.

In 1930 we hatched a large number from eggs. They were placed in cages in a grain field at Edmonton, where they lived under conditions which differed little from those in their normal free life. There is a heavy annual mortality due, chiefly to their cannibalistic habits during the summer months. None die during the winter and all specimens which were given cages to themselves finally matured into beetles. The first of these matured in 1933, since they would have laid their eggs in 1934, the shortest life cycle obtained was four years. Each year thereafter, more of them matured until 1938, when the last five turned into beetles which would have laid their eggs in 1939.

A second and larger series of cages was started in 1932. As before the shortest life-cycle recorded was four years. The longest observed cycle for other individuals was 12 years. Unfortunately two only survived to this final year and we do not know whether we have yet discovered for how many years some of our most slowly developing wireworms will remain, as such, in the soil. The majority matured and pupated at the end of the sixth or seventh

year but when an infestation is heavy, it must be assumed that many individuals will exceed even this lengthy period.

It follows from this long life-cycle that the total number of wireworms in any field will not vary much from year to year. The damage they do, however, may vary greatly. It follows also that where wireworms occur their numbers will tend to increase for the first ten or twelve years in fields under cultivation. In virgin soil they appear to thrive only where the soil is unusually loose and damp. Where such areas occur they are referred to locally as 'loose-top'. They are usually comparatively small, some two or three rods in diameter. Loose soil texture is ideally suited to the egg-laying requirements of beetles. These beetles are unable to burrow into firm earth. In hard virgin sod they fail to penetrate into the soil to a sufficient depth to safeguard their eggs from destruction by heat and desiccation. In loose-top they can however burrow readily to five or six inches, at which depth all of the eggs they lay are practically certain to hatch. The usual practice employed for summerfallowing is to plough deeply in May or June. This is the time when the beetles are laying their eggs. By this method the soil texture of the field is modified into loose-top, and the beetles can burrow readily anywhere to plough depth.

Feeding habits

Newly hatched wireworms feed on the roots or germinating seeds of grain and grasses; it is doubtful whether most weed seeds and roots are suitable for them. If they do not find suitable food within about a month they die of starvation. After passing their first winter they can live for at least two years without food other than humus which is universally present in soil. From this the impossibility of starving half-grown wireworms by clean summer-fallowing will be appreciated.

When the ground freezes up all wireworms become inactive until the following spring. As soon as the ground warms up they resume activity. When a field in which they are present has been seeded with grain, they attack the seeds and eat out the starchy food material that they contain. The plant is thus starved, and it fails to come above ground. Very small wireworms frequently eat only the embryo, particularly if the soil is inclined to be dry. The result is the same—the plant does not appear above ground.

Having destroyed one seed the wireworm moves, usually along the drill row, and destroys the one next to it. In this manner a single fairly large wireworm may prevent a dozen or more adjacent plants from appearing above ground. A little later in the season, when undamaged plants are above ground, the wireworms turn

their attention to the stems and bite through them well below the ground level. Plants attacked in this manner do not fall over, as do those that are killed by cutworms. The leaves wither and become tightly rolled up. This is very characteristic of wireworm damage.

Still later when the plants are beginning to stool out and the stems are becoming thicker and tougher, the wireworms no longer cut them off completely. They bite a small hole through to the central shoot and feed on it only. As a result the central leaves of the plant turn yellow and die, though the older ones may show no sign of damage above ground.

At about this time, which is early in June, the wireworms tend to leave off feeding. By the time the plants are fully stooled out little further damage is seen. Wireworms never come above ground. They feed only in fairly cool moist earth. Early in the spring they are able to come nearly to the surface of the soil to feed. As this dries out and heats up later in the season they burrow more deeply to cooler, moister earth. By the middle of June in normal seasons they are below the level of the seed, and such feeding as they do is confined to the roots which, as a rule, are not very seriously injured. It is the variation in moisture and temperature at various depths in the soil and in relation to the stage of plant development which is responsible for the fact that a similar wireworm population may in one year cause very serious damage, and in the next year no damage at all.

Pupation.

By the middle of July all full-grown wireworms work their way upwards in the soil and come to rest at about two to four inches from the surface, provided the soil is not too hot and dusty for them to make a small cavity in the ground in which to pupate. Here they soon turn into delicate white pupae which are very easily crushed if the soil that surrounds them is disturbed. When, early in August, these have turned into hard-shelled beetles they are very difficult to destroy.

Control of wireworms.

Pupae are readily destroyed if the soil that surrounds them be disturbed. At no other stage in their development can wireworms be destroyed mechanically with a cultural implement. It is only at this time of the year, therefore, that deep ploughing is of value in reducing their numbers by mechanical destruction.

We recommend, therefore, the following modification in summer-fallow methods in fields that are badly infested with wireworms.

1 Early in the spring, cultivate to a depth of not more than 2½", the shallower the better. This will encourage the germination of weed seeds that are near the surface. It is essential that the sub-surface soil be kept as firm as is possible during the egg-laying period in order to induce most of the beetles to lay their eggs in the superficial layers.

2 Repeat shallow cultivation, as often as is necessary to destroy all weed growth, till the middle of July. This loosens the surface and packs the ground below the depth of operation, thus encouraging shallow oviposition. Early in the season wireworms are near the surface and many of them are exposed to destruction by birds. Each operation, also, brings many of the eggs which are laid in the loose earth right to the surface where they are certain to perish. Finally it should result in the germination and destruction of all volunteer grain on which any small wireworms that manage to hatch thrive better than on anything else.

3 During the last half of July, plough or cultivate about one to two inches more deeply than formerly. If the earlier work has been properly done all mature wireworms will have come to the surface layers of the firm soil for the purpose of pupation. This somewhat deeper cultivation will destroy nearly all of the pupae. Do not, however, set the implement to work any more deeply than is necessary to break about an inch into the firm soil. The more the subsoil is loosened the more easy it is for any beetles which may survive to burrow deeply in the following spring for egg-laying.

It is essential that this somewhat deeper cultivation be not delayed until August. The beetles are then formed and they will be in no way damaged by the plough or cultivator.

This method of summerfallowing should be followed consistently in all badly infested fields. Its employment in other fields, in which wireworms are not numerous, will reduce the danger of serious infestation. Deep ploughing or cultivation should at all times, be avoided. If for any reason it is essential it should be deferred till after the middle of July.

It must be borne in mind that summerfallowing by this method cannot have a very marked effect on the number of destructive wireworms that will be present in the following year. The greatest damage is done by wireworms which are from three to five years old, and their numbers will not have been greatly affected. It is a long term program designed to reduce wireworm numbers.

Cultural methods for reducing wireworm feeding.

Experiments conducted at the Dominion Experimental Station at Beaverlodge through the courtesy of the Superintendent, Mr. W

D. Albright, and with the aid of a grant made for that purpose by the National Research Council have tended to confirm the recommendations which have been arrived at by other investigators as follows.

- 1 Seed only in a well-prepared seed-bed in which moisture is close to the surface.

- 2 Seed as shallowly as possible with the assurance that the seed is well down to moisture.

- 3 Combined with shallow seeding (2") use a press drill, or press-attachment, or else pack at right angles to the drill-rows immediately after seeding. In our experiments we found more damage when grain was seeded 4" to 5" deep with a press drill, or when it was packed, than there was when it was simply seeded at similar depths with a disk drill.

- 4 Grain seeded as late as the middle of June is not likely to be damaged seriously. Wireworm feeding is nearly over for the year by this time. It is useful to bear this in mind in connection with reseeded, even though it is then too late to reseed with wheat.

It is impossible to state, for all seasons, whether early or late spring seeding is dangerous. When the soil is really cold wireworms hardly feed at all, though, at the same temperature, the grain is softening prior to germination. This gives the grain a start so that it can grow rapidly when the soil warms up. If, however, the soil remains somewhat cool, and subsequent growth is slow, the wireworms have longer to feed on the germinated grain and small plants. Generally speaking, early seeding is preferable, but rapid growth is a matter of great importance in reducing damage.

Use of fertilizers.

Everything that is possible should be done to encourage rapid germination and development of the plants. In many districts in Alberta there is a serious shortage of phosphates in the soil. Phosphates applied at the time of seeding encourage early development of roots. This makes the plants more resistant to wireworm damage. Where phosphate shortage is indicated, this shortage increases wireworm damage. At Beaverlodge, Mr. Albright finds that applications of phosphates do not have as stimulating an effect on wheat as they do in some other districts, and their application did not appreciably reduce wireworm damage.

Chemical treatments.

Claims are made frequently to the effect that grain treated with coal oil, turpentine, lime, tar, and a variety of other materials is less

subject to wireworm damage than is seed not so treated. When these materials have been tested under controlled conditions none of them has been found to be of the slightest value for this purpose. Several retard germination and do more harm than good. In fairness to those who make these claims it should be remembered that, on account of variations in climatic conditions, the amount of wireworm damage varies greatly from year to year. These materials are tried in fields that have suffered abnormally heavy damage during the previous year. A perfectly normal decrease in damage during the following year is naturally attributed to the treatment that has been employed, even though it has nothing whatever to do with it.

A number of recently developed insecticides are effective in soil treatments or seed treatments for the control of wireworms. The best of these is lindane, the gamma isomer of benzene hexachloride. For soil treatment this is applied as a dust or as a spray at from $\frac{1}{2}$ to 1 pound per acre, which is then promptly cultivated in to the top 6" of soil. Seed treatment preparations are available in which lindane is combined with a mercurial fungicide. About 1 oz. of lindane per bushel of seed is required. Do not exceed the rate of application recommended by the manufacturer, do not treat earlier than necessary, and do not leave treated seed exposed to sunlight.

In this connection, however, it should be borne in mind, from what has been said regarding the habits of wireworms that a single application of a really effective poison to the soil should reduce the wireworm population to insignificant numbers for many years. It is both unnecessary and unwise to make such applications more often than once in five years.

Whenever grain is treated with formalin, germination will always be retarded. Thus, inevitably, increases wireworm damage. This unnecessary damage can be avoided by treating grain only with materials other than formalin. There are, in addition, indications that a recent treatment of a field with 2,4-D may somewhat retard the germination of wheat and, in this manner, increase wireworm damage.

For further information see:

Kang, K. M., and others, "Wireworm Control in Western Grain Fields." Special Pamphlet No. 17, Division of Entomology, Ottawa, 1942.

FALSE WIREWORMS (*Blacus hispidulus*)

FIG. 5.—False Wireworm. A Full-grown false wireworm. (Note that hinder end of the body is pointed.) B Adult beetle standing on its head as it does when it is disturbed. These beetles must not be confused with the rapidly running fiery hunters (see Fig. 7). Natural size.

Distribution.

These are rarely seen anywhere except on the open prairie. Most abundant in the south and east, where rainfall is light.

Life-history and habits.**Beetles.**

Very clumsy black beetles, about 1" long. They walk slowly and have the ridiculous habit of standing perfectly still on their heads when they are mildly alarmed. In addition to this, they frequently fall into gopher holes, and take so long to drag themselves out that many people think they must have some relationship with gophers. Young beetles first appear above ground in the late summer. They feed on the foliage of a variety of weeds till the weather turns cold, when they wander extensively over roads, etc., in search of suitable places in which to pass the winter. The most favourable location for this purpose is under dense masses of dead weeds. Here they remain till the spring, when they resume activity and feed on young Russian thistle and other weeds. At about the middle of June they lay eggs just below the surface of the soil, but continue to live till the following fall, or even longer.

False wireworms.

The larvae closely resemble wireworms. They are, however, cylindrical and the end of the body is rather sharply pointed. The best character for distinguishing them is, however, their extreme activity. Place one on the open hand. It will immediately whip its body around in all directions till it succeeds in jumping to the ground, into which it will immediately burrow. No wireworm does this.

Young false wireworms hatch from eggs in July and are half-grown by winter. In the spring they feed in a somewhat similar manner to wireworms, though they do far less damage. They are mature by August when they pupate in the soil and soon turn into

beetles, which come to the surface immediately and feed on weeds until low temperatures force them to seek winter quarters.

Economic importance.

False wireworms do comparatively little damage. They attack grain less extensively than do true wireworms, and they appear to prefer nibbling at the roots to feeding on the stem. There are several different species of false wireworms, and Criddle has observed, in Manitoba, that some of them come above ground at night and feed on the blades and stems of grain plants. We have not noticed this in Alberta, though doubtless the habits are the same here as elsewhere. Such damage as they do renders it advisable to keep down their numbers as far as possible.

Control measures.

The most practical control measure for false wireworms is that of keeping the soil surface free from dead vegetation during the winter. Abnormal abundance of false wireworms in any field can nearly always be traced to large quantities of Russian thistle or mustard, particularly two winters previous to their greatest abundance. In no stage of development can false wireworms be starved. They can be bred from egg to adult in damp soil which contains no living vegetation. This may be why they cause much less damage than wireworms.

CUTWORMS AND OTHER CATERpillARS OF MOTHS

CUTWORMS

There are over 200 different kinds of cutworms in Alberta. Only about 50 of them ever feed on grain. Fortunately, the great majority of these occur in such small numbers that the damage they do is negligible. A few species, however, increase in number very rapidly when climatic conditions are favourable to them, and during these years of cutworm outbreaks they are liable to be extremely destructive to grain crops.

The habits of those species that have caused the greatest damage in Alberta have been carefully studied, but those of the less common ones are not well known. Unfortunately it is possible that certain climatic conditions or modifications in cultural practices may, at some future date, permit outbreaks of these less common species.

What to do about cutworms *extremus* is given.

Should a farmer, at any time, find that his fields are heavily infested with a cutworm that he is unable to recognise, he can very quickly find out enough about its habits to decide upon the best immediate steps to take by the following procedure

1. Note their average size. If they are already nearly $1\frac{1}{2}$ " long there is not much cause for alarm. They are practically through feeding for the year and will disappear in a few days' time.

2. If they are smaller observe, in the field, on what they are feeding or have fed. If only on broad-leaved plants they are in all probability harmless to grain. If, however they feed on grass or volunteer grain they are liable to be destructive. When there is too little variety of growth in the field for their food choice to be ascertained, collect a few and place them in two sealers. To one sealer add a few leaves of weeds, such as dandelion, or some alfalfa and some blades of grain. To the other add only blades of grain. By observing what they have eaten on the following morning, you will know whether they prefer broad-leaved plants or grain, and also whether they will eat the latter when there is nothing else available.

3. If they eat grain observe, in the field, whether most of their feeding is done from above or from below ground. If they feed above ground it is probable that bait, broadcast as recommended on page 41, will control them. When, however, it is seen that the

plants have been attacked below the ground level it is very unlikely that bait will prove to be effective.

4. Observe whether the cutworms are above ground by day. If so, and the majority of them are crawling in the same direction, bait can be applied in furrows ploughed across their line of march (see page 42). This will greatly reduce the amount of bait that is required to control them.

A word of caution is necessary. The habits of cutworms vary considerably with temperature and with soil moisture. On cold days or nights they feed very little and tend to stay below ground. When the soil is dry at the surface several species remain below ground and feed extensively there, even though they move and feed freely on the surface when the soil is damp.

One should, therefore, repeat field observations under as many climatic conditions as possible. In the meantime, if there is any doubt as to their habits, send a few specimens to the University at Edmonton or to the Science Service Laboratory at Lethbridge for determination and advice.

Habits of all injurious cutworms.

Egg-laying habits of moths.

In so far as is known all of the moths of cutworms that are liable to be injurious to grain in Alberta lay their eggs exclusively in the soil and never on weeds or other vegetation. This is not true for all kinds of cutworms, but it certainly applies to those grain feeders which have been studied in detail.

As a general rule, the moths lay their eggs only where it is easy for them to place them beneath the surface of the soil. The eggs are laid in August or September, but those of the majority of the species do not hatch till the following spring. This necessitates some protection. The moths, however, are not provided with powerful organs for digging into soil, as are grasshoppers. They are forced, therefore, to lay their eggs in beds in which either they can get under loose clods of earth or there is a sufficiently loose layer of earth on the surface for them to be able to rub small holes in it with the ends of their soft bodies, in order to place their eggs below ground. Egg-laying is usually accomplished just before sundown, or after dark and, for this reason, is not often observed.

Habits of cutworms.

Cutworms which hatch from their eggs in the fall feed freely on weeds till freeze-up, when they burrow just beneath the soil surface and remain inactive until the following spring. Those which do not hatch until the spring usually do so soon after the crop has been

seeded. Depending on what species of cutworm they are they either remain continually below ground and feed on the underground parts of the plants or they come above ground to feed and retire into the soil when they have finished. As a general rule, all of them remain below ground for the greater part of the day, and are most active at night time.

Pupation.

When a cutworm is about 1½" long it is full-grown. It now ceases to feed, burrows down to firm earth and there makes a small cavity in the soil. In this it changes to a reddish pupa or chrysalis, from which, at the end of about a month, the moth escapes and works its way to the surface of the soil.

Habits of the moths.

Cutworm moths feed only on nectar from flowers. They are most active at night-time, and many species are strongly attracted to lights and are sometimes a nuisance in houses. They are harmless to grain except in so far as they lay the eggs from which will come next year's crop of cutworms.

Causes of cutworm outbreaks.

Generally speaking, injurious cutworms increase in numbers when rainfall has been below the average in May and June. Two dry seasons in succession are necessary before a serious outbreak occurs. This is because ample rainfall during these months favours both parasites and diseases.

Termination of cutworm outbreaks.

It is commonly believed in many quarters that rain kills cutworms directly. This is not so. Rain greatly reduces their feeding activities for as long as the soil remains moist. It also strengthens the plants, allowing many that have been only slightly damaged to recover. Rain in May and June does greatly reduce the number of cutworms that will be in the district in the following year, because it allows parasites and disease to destroy more of them before they develop into egg-laying moths. On page 47 will be found Mr. Seaman's formula for forecasting the abundance of pale western cutworms from records of wet days in May and June.

Important enemies of cutworms.

Fiery-hunter ground beetles.

These beetles occur over the entire province. There are several species, all of which are mostly black in colour. Some of them have rows of small metallic red or greenish pits on the wing-covers.

They are about 1" long. They run very rapidly over the soil and occasionally dig energetically into it with their long legs. When so doing they are hunting for cutworms upon which they feed.



FIG. 1. Enemies of cutworms, frequently seen in grain fields.—A, Fiery Hunter ground beetle; B, Cutworm lion, which is the larva of A, C Solitary wasp. All natural size.

The beetles lay eggs in the soil during the spring. Black grubs hatch from these and grow rapidly until they also are about 1" long. These grubs are called cutworm lions, since they feed entirely on cutworms. They never come above ground.

The number of the beetles and of their grubs that survive from year to year is entirely dependent upon the abundance of cutworms. Their number cannot be permanently increased by breeding and liberating them.

These beetles must not be confused with the rather slender slow moving and clumsy black beetles that are common in the southern part of the province. These are the adults of false wireworms (see page 35).

Solitary wasps.

During the season of cutworm activity these large slender black insects, with four smoky black wings, search the ground actively for cutworms. A female wasp will dig energetically with her long legs when she locates a cutworm below ground and soon uncovers it. She stings it in such a manner that it will be paralyzed, but not killed. Then she drags it to a small hole in the ground, lays an egg on it, and buries it. From the egg a small white grub hatches which eats the helpless cutworm.

Parasites of cutworms.

The most important parasites of cutworms are reddish wasp-like insects, and bristly flies which somewhat resemble common blow-flies. Although they are of more importance in killing cutworms than are fiery hunters and solitary wasps, they are less often observed by farmers.

Control Measures.

Cultural.

Since all of our injurious cutworm moths lay their eggs only in loose earth, summerfallow should never be worked while the moths are flying. The dates of egg-laying differ slightly with the various species, but the majority of moths are laying eggs throughout August and September.

For this reason fallow land should be well worked and be quite free from weeds by the end of July. It need not, then, be touched again during the season. Any subsequent growth of weeds will not mature seed, neither will it remove much moisture from the soil. If desired, however, cultivation can be resumed after the end of September.

During the idle period precautions must be taken to keep stock, people and vehicles out of the field. These will break any surface crust that has formed, and thus will give moths an opportunity to lay some of their eggs in the field.

Since it is impossible to avoid loosening the surface of the soil when crops are being harvested during the egg-laying period, there is no practical method for protecting these fields from the moths. In this connection it should be remembered that the use of a combine after the first week of September will avoid breaking the crust during the period in which most of the eggs are being laid.

When practical during periods of bad cutworm outbreaks, it is advisable to seed wheat only in properly prepared summerfallow. If this cannot be done some benefit can be derived from deep fall ploughing. If this is 6' deep and the furrows are turned completely upside-down, the majority of the eggs are buried so deeply that few of the very small unfed cutworms will reach the surface in the spring. This control measure cannot, however, be recommended for use in any district in which there is much likelihood of soil drifting.

Bait.

For any cutworms that feed above ground, bait, if properly applied, probably will prove to be an effective control measure. For those that feed entirely below ground it will never be of sufficient value to warrant the expense or the labour of employing it.

On page 16 is described the method for preparing grasshopper bait. The same procedure should be adopted, the only difference being that no sawdust is employed in cutworm bait.

The following recommendations, condensed from Dr. K. M. King's pamphlet on red-backed cutworms, apply to all other surface feeding species:

"For success three conditions are essential—uniform spreading, application during the evening, and favourable temperature. It is essential that a warm, but not too hot, evening be chosen for its application. If a thermometer in the shade registers less than 50°F at sundown, it will be too cold for good results, and the bait should not be put out. Particularly good results can be obtained when the soil is moist, hence whenever it is possible, spread the bait soon after rain if the temperature is suitable."

Not more than 10 pounds of the prepared bait are required to poison an acre, but the scattering must be uniform since many cutworms do not crawl far in search of food.

Whenever it is noticed that any kind of cutworm has the habit of crawling in large numbers across fields and that they are all moving in approximately the same direction, it is economical in material, and in labour to poison them in specially prepared furrows which are ploughed at right-angles across their line of march. In addition, much cheaper baits than bran can be employed.



FIG. 8.—Sections of trap-furrows. Left, vertical-sided furrow for use in damp soil, right, dusty-sided furrow for use in dry soil.

Furrows for use with bait are prepared as follows. If the soil be sufficiently moist to permit ploughing a vertical-sided furrow, a plough with a coulter must be used and the earth thrown out towards the advancing cutworms. The furrow should be as deep as is possible, and every precaution must be taken to assure that its side is vertical and unbroken (see Fig. 8).

More frequently than otherwise such a vertical-sided furrow cannot be prepared. Either the soil is too dry or it has been already cultivated so that its side crumbles. Under these conditions a dusty-sided furrow will give better results. No coulter is necessary. Plough a deep furrow throwing the earth away from the advancing cutworms. Immediately after ploughing, before clods of earth in the furrow have dried out, drag a heavy log along it. One or two horses hitched with a logging chain to one end of a heavy gate-post, on the rear end of which the driver stands to increase its weight, has given excellent results. This breaks up all lumps of earth,

leaving a fairly steep and crumbly slope (see Fig. 8), which is impassable to cutworms since the small particles of earth move under them. After a shower of rain, and as soon as the surface crust of earth has dried out, the log must be again drawn through the furrow.

Poisoned bran as recommended for broadcasting, can be scattered along the furrow at the rate of 10 pounds to 60 or 70 rods. Though the best results will be obtained when the bait is applied in the evening, the furrow can be baited at any time of the day at which cutworms are seen to be attempting to cross it. Even though they would not at the time feed readily on broadcast bait few of them fail to stop and eat some of it after one or two unsuccessful attempts to crawl up the side of the furrow.

A much cheaper bait can be prepared from green vegetation. In the field look for any fairly rankly growing weeds on which the cutworms have fed. Stinkweed is a favourite with many of them, and lambs-quarters or pigweed with others. Pull about 50 pounds of this vegetation, place it on a floor and sprinkle water over it until it is thoroughly moist. While turning it over with a fork, shake into it, a little at a time, one pound of white arsenic or Paris green. Alternatively the vegetation may be sprayed with any of the materials mentioned under grasshoppers.

Scatter the poisoned plants 6' to 9' apart along the furrow so that ten pounds will treat about 50-60 rods. Since the vegetation remains moist longer than does bran, it is a preferable bait. The cost of materials, also, is only about 15c per mile of furrow when white arsenic is used.

Re-seeding field after the crop has been destroyed by cutworms.

Some species of cutworms, particularly those which are active on the surface of the soil by day, leave a field as soon as they have eaten all the vegetation in it. When the damage has been caused by this type of cutworm immediate re-seeding is safe, though it is advisable to protect the field with furrows (see page 42). These need not be baited unless it is seen that cutworms are attempting to cross them.

Other types of cutworms, however, remain in the devastated fields and eke out a bare existence on old and dead vegetation and by feeding to some extent, on each other. When such cutworms are present it is never safe to re-seed till they are mature and have ceased to feed.

We cannot give a definite date on which re-seeding is safe since, even in the same season, cutworms mature more rapidly in some fields than they do in others.

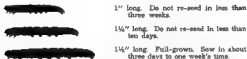


FIG. 3.—Diagram to assist in ascertaining when re-seeding is safe

The diagram given above, can be used in connection with all cutworms in order to determine when re-seeding is safe. Collect a number of cutworms from the soil of the damaged field, and pick out a few that are of average size. Drop them into a glass of water. Within ten minutes all will straighten out and appear to be dead. Dry them on a piece of blotting paper and compare their length with the figures on the diagram.

Unsatisfactory control measures that are sometimes recommended.

Coal oil, turpentine, or any other material applied to the seed has no effect on cutworm activities, neither has lime, salt or sulphur applied to the soil.

Rolling will never kill cutworms. If the soil be damp it may slightly hamper their movements below ground. Harrowing has the opposite effect and it, too, is harmless to the cutworms.

Seeding with a press drill may be slightly beneficial in some cases, but if the drill is purchased solely for this reason it is unlikely that it will prove to be an economic investment.

Light traps, placed in the field, may capture an enormous number of moths. Since over 85% of these are males and many of the remainder are females which have already laid their eggs, traps are of no practical value.

The application of DDT and other chemicals for the control of cutworms has given conflicting results. None can as yet, be recommended for general use in grain fields.

FALE WESTERN CUTWORM (*Agrotis orthogonia*)

Distribution.

The normally treeless prairie of Alberta, particularly in the southern third of the province. There is little likelihood of this cutworm ever extending its range of activity into those parts of our province in which the aspen poplar is native.

Life-history and habits.

The eggs are laid only in loose soil during the last three weeks in August and the first half of September. Provided it does not modify the condition of the soil surface, the presence or absence of green vegetation in the field appears to have no effect whatever upon the moths in the selection of places in which to lay their eggs.

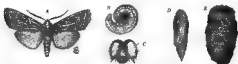


FIG. 10.—Pale Western Cutworm (*Agrotis orthogona*). —A. Moth (greenish-grey in colour), B. Cutworm (usually slaty-grey), C. Head of cutworm, enlarged to show smoky black A-shaped mark in front, D. Chrysalis, or pupa, E. Pupal cell, composed of earth. (In this figure the moth has already escaped through the hole that it has made at one end.) All except C, natural size.

The cutworms hatch from the eggs toward the end of April. The small cutworms, under favourable conditions, remain permanently below ground until they are full-grown in early June. Whenever the soil is wet, or if it is very hard, they are unable to move freely from plant to plant beneath the soil surface. Under these conditions they move after dark above ground but burrow into the soil, when this is possible, as soon as they find food.

Special control measures.

Summerfallowing.

For pale western cutworms, more than for any other species, it is essential that the soil surface be protected by a crust throughout August and the first half of September (see page 41). During outbreaks of this cutworm, only this method can be relied upon to hold damage in any given field to a minimum.

Delaying spring seeding after cultivation.

Pale western cutworms which have just hatched can live for a long time without food if they have never had anything to eat. Once they have fed, provided they are still very small, they may be starved. This observation was made at the Science Services Laboratory at Lethbridge. It is recommended that fields in which there is danger of infestation be cultivated in the spring, soon after a green growth of weeds and volunteer grain has appeared, in such a manner that all of this growth will be destroyed. The field should not, then, be seeded to grain in less than ten days after this cultivation has been completed.

Use of a test strip of grain in the spring.

Another method for reducing unnecessary losses in fields which are heavily infested with eggs is to ascertain, before the field is

seeded, the approximate number of cutworms that are present. This can be done by the following method:

Before seeding any of the fields that you believe to be safe seed two single drill widths of wheat diagonally through the field from the opposite corners. When this wheat is about 4" high examine it for cutworm damage. Remember that the smaller cutworms feed on the shoot before it emerges from the ground. This damage is manifest as small holes or notches in the first blades. This indicates the presence of cutworms as much as do plants that have been cut at ground level a little later in the season. If on an average 15-20 plants to the square yard have been damaged, it is not safe to seed the field. It should be summerfallowed or seeded to green feed in June when the diagram (page 44) indicates that seeding is safe.

Choice of crops in fields that are believed to be infested

Pale western cutworms prefer grain to broad leaved plants, such as flax. Flax is, however, not immune from attack when there is nothing else for them to eat. It is useful for seeding in fields after the cutworms in them have matured. Corn suffers very heavily on account of the comparative scarcity of plants on which the cutworms can feed.

Treatment of fields in which infestation is patchy

In many fields the cutworms may be confined early in the season, to small areas scattered throughout the field. In the fall most of the field may have borne a crust whereas these areas, which are often small knolls had the crust broken by wind erosion or by some other cause. Do not mistake earlier hatching in patches for patchy infestation. If, however, the rest of the field shows no sign of damage, plough a deep furrow around each badly infested area, or, if the soil is sufficiently moist to consolidate readily at the surface, simply drive a car or tractor around these areas. This tends to prevent the cutworms from spreading through the field. It cannot stop them entirely but it may reduce the spread by 50%. Under these circumstances it is also a sound practice to scatter some poisoned bait in the heavily infested area, and to harrow it into the soil before the furrow is ploughed around it.

Forecasting outbreaks of pale western cutworms.

Much loss from these cutworms could be avoided if farmers knew when to expect outbreaks in order that they could pay especial attention to their summerfallowing methods during the previous summer. It has been shown that outbreaks are due to lack of rainfall in the previous May and June. Seamans has prepared

a rough guide that can be used by all farmers in order to find out whether cutworms are liable to increase in numbers in their district. The following is a quotation from his pamphlet "One-quarter of an inch of rainfall is sufficient to bring the cutworms to the surface of the ground. If the sun is bright after rain they seek shade and are hidden, but if the weather remains cloudy they may become active and behave very much like ordinary surface-feeding cutworms. It has been found that when the fields are too wet to use a disc-harrow the cutworms are also likely to be on the surface, and a day with the soil in such a condition, whether raining or not, must, therefore, be considered as a 'wet' day in forecasting. When it is not actually raining, an observation in the field will be required to determine the moisture condition of the soil.

"If there are less than ten 'wet' days during the period of cutworm activity there will be an increase in the number of cutworms the following year.

"If there are between ten and fifteen such days, there will probably be some decrease in the numbers of cutworms next year.

"If there are more than fifteen 'wet' days, little trouble may be looked for from this insect the following year."

In this connection we would point out that this refers only to the increase or the decrease in numbers of cutworms from year to year. If in any year in which there were less than ten "wet" days during the period of cutworm activity cutworms were already sufficiently numerous to be causing appreciable damage, a serious outbreak can be anticipated in the following year. When, however, cutworms were very scarce, the same small number of 'wet' days probably will not result in serious consequences. At least two successive seasons that are favourable to cutworm increase are usually necessary before a serious outbreak occurs.

For further information see:

Jacobson, L. A., and McDonald, H. "Pale Western Cutworm Control," Division of Entomology Ottawa. Processed Publication 62. Revised 1948.

RED-BACKED CUTWORM (*Homia schlegelii*):

Distribution.

Outbreaks of this cutworm are most frequent in those parts of Alberta in which the aspen poplar is native. They may however, occur anywhere in the province.

Life-history and habits.

The eggs are laid in the soil from the last week in July until the end of August. From this it will be seen that the moths begin to lay their eggs about two weeks earlier than do those of the pale western cutworm.

We have never observed egg laying in the field. The reason for this is that the moths apparently lay them only after dark. When they are confined in cages these moths lay all their eggs in the soil and under these conditions, they deposit them in the loosest soil available. They thus appear to have somewhat similar habits to the pale western cutworm moths.

In the field we can ascertain where the majority of eggs have been laid only by observing where the young cutworms are most numerous early in the spring. This indicates that the moths lay their eggs, whenever it is possible near vegetation that will provide suitable food for the cutworms in the spring. The condition of the soil surface is of less importance than it is for the pale western cutworm. No field has ever been found to be infested in the following spring provided it was free from green vegetation during the egg laying period. The favoured food of this cutworm includes a variety of broad leaved plants. Sweet clover alfalfa a great variety of garden produce and weeds such as stinkweed are attractive to the moths during the egg laying period. Where these grow in profusion it would appear that a slight crust on the soil surface fails to deter the moths from laying their eggs among the plants. We have observed that fields which contained much stink weed even though they became crusted on the surface in July and August were severely infested with red backed cutworms in the following spring. In these fields, it should be noted the crust had provided a complete protection from the pale western cutworm moths, which were also very abundant in the district.

The cutworms hatch from the eggs towards the end of April. They are mature by the middle of June. Unlike the pale western cutworm they are liable to come to the surface of the soil quite freely even by day and to feed on the surface almost as much as they do below ground. When large numbers of eggs have been laid in a field that was later sowed to wheat or other grain they will feed on it at least until they are sufficiently well developed to move elsewhere in search of something more to their liking. They are less restless and feed more extensively when they are in barley or oats than when they are in a wheat field. In the latter by the time they are half grown they frequently come to the surface by day and move rapidly, all travelling more or less in the same direction, over the surface of the soil.

Special control measures.

Summerfallowing.

Summerfallow should be absolutely clean by the middle of July and provided it does not become generally weedy should then be left

alone until the end of August in order to take advantage of any crust that may form. If the field contains much green growth and is merely cultivated in August it will, in all probability, be rendered very attractive to the moths, since much of the vegetation is not covered and the soil surface is loosened up.

Bait.

Since these cutworms feed above the ground as well as below, poisoned bait, under favourable conditions of application, will often prove to be of value. Read carefully, on page 42, the only conditions under which bait can be successfully employed.

At any time in which the cutworms are seen to be moving towards or through a grain field over the soil surface, large numbers of them can be destroyed by the use of baited furrows ploughed across the r line of march (see page 42). In this connection we have obtained the best results by employing stinkweed bait.

Choice of crops in fields that are believed to be infested.

Since broad-leaved plants, such as flax or sweet clover, are preferred as food by these cutworms, it is advisable to seed grain in fields in which they are believed to be present. Wheat is the safest grain to grow since, although the small cutworms feed as freely on it as they do on barley or oats, as they grow larger they attempt to move elsewhere. Furrows for baiting should be prepared around the edges of badly infested wheat fields in order to trap and to kill any cutworms which attempt to leave them and to enter neighbouring fields.

For further information see:

Kang, K. M., "The Red-backed Cutworm and its Control in the Prairie Provinces," Dept. Agric. Pamphlet 68, new series, 1926. Division of Entomology, Ottawa.

ARMY CUTWORM (*Chortographa auxiliaris*).

Distribution.

This cutworm has appeared in numbers, sufficient to constitute a serious menace to grain fields, only in the extreme south of Alberta. It is, however, widespread throughout the province and during recent years has been far more numerous as far north as the Peace River district.

Life-history and habits.

The eggs are laid in the soil during September. They hatch a few days after they are laid. The cutworms begin immediately to feed on any green vegetation that is present in the fields at that time of the year. They grow rapidly and are half-grown by the time the soil freezes up. They remain inactive just beneath the

soil until the following spring and, as soon as the frost is out of the ground, they come to the surface and move around in search of food. Army cutworms never feed below ground, but tend to climb up plants and to feed on the blades. When food is plentiful they remain below ground by day and come to the surface and feed only at night. When food is scarce they may be very active by day and, if the sun is shining, they will all move away from the sun in search of food.

Since all feeding is done above the surface and is confined largely to the blades, individual army cutworms do less damage than do those species which cut off the plants at the base. It is only when they are very numerous that they are liable to ruin grain crops.

Most of the cutworms mature by the first week in June.

Special control measures.

Summerfallow

Outbreaks of army cutworms generally develop far more rapidly than do those of other cutworms. They are unlikely to last for more than one year. Farmers, therefore, rarely have any warning of them, though two wet harvests in succession should be regarded as a danger signal. Since the eggs are laid by preference in freshly worked soil a crusted surface in September may afford some protection. At any time during the spring, however, fields that were free from eggs in the fall may become infested with migrating army cutworms.

Bait

Where these cutworms are numerous they are usually first observed when the fields are being prepared for seeding early in April. They are then from $\frac{1}{2}$ " to 1" long. If, at that time, care is taken to bury all green vegetation nearly all of the cutworms will have left the field before the wheat is above ground. Precautions must, however, be taken to protect the field from later invasions, particularly along its southern side. This can be done by preparing and baiting furrows as described on page 42. Sunk-weed has proved to be superior to bran for the bait, and we would recommend its use wherever it is available. Either one furrow, or two of them at a distance of about a rod apart, should be ploughed along the edge of the field. Scatter the bait at any time of the day when the cutworms are seen to be entering the furrows in large numbers, and replenish it every three days for as long as migrations continue.

When the cutworms are found to be already present in large

numbers in growing grain they can be readily controlled with bait broadcast as described on page 42, or with sprays.

Cause of outbreaks

The moths of the army cutworm lay about 1,000 eggs. This is many more than any other common cutworm. This accounts for the sudden appearance of the pest. Seaman has shown that, if the soil be dry when the eggs are laid and it remains so for a few weeks, most of the eggs perish. In a wet fall, however, nearly all of them hatch with the result that the cutworms are very numerous in the following spring. Since it is unusual for southern Alberta to experience two wet falls in succession, outbreaks of the army cutworm are usually terminated as suddenly as they occur.

For further information see:

Seaman, H. L. "The Army Cutworm." Division of Entomology, Dept. of Agric., Ottawa. Pamphlet 102, 1929.

EARLY CUTWORM (*Agrotis triticea*).

Distribution.

The open prairie areas of Alberta, particularly in the south.

Life-history and habits.

Eggs are laid in the fall and they hatch a few days later. The cutworms feed on weeds and are nearly full-grown by the time the soil freezes up. As soon as the frost is out of the ground in the spring they resume activity. They mature about the middle of May.

Although these cutworms can be found in the fields every spring they have never been very numerous in Alberta. They prefer weeds to grain and in the small numbers in which they have occurred here we consider them to be very beneficial since they harbour many parasites which later attack and reduce the numbers of the more injurious cutworms. In addition, they usually finish feeding before any seeded crops are above ground. King states, however, that they were unusually abundant in several localities in Saskatchewan in 1925, and that they caused serious injury to grain. When they are observed in large numbers he recommends delaying seeding until about the last week in May. Poisoned bait is not effective for the control of this cutworm.

GLASSY CUTWORM (*Eudemis dorsatator*).

Distribution.

The entire province. The moths of this cutworm are very abundant every year, but the cutworms have never been found in very large numbers in grain fields.

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Life-history and habits.

It is not known for certain where the majority of the eggs are laid. It has been suggested that they are laid, by preference, on or in the vicinity of grass, though there is a record of their being laid at the base of a tree. In Alberta we have found these cutworms in the largest numbers in brome sod, where they do comparatively little damage.

Although they occur sparingly in clean grain fields, we have found them in destructive numbers only in fields in which an unusually large amount of grass was present. Criddle found that, in Manitoba, they feed on grass such as wild barley grass in preference to grain.

The eggs hatch soon after they are laid, and the cutworms are nearly full-grown by the time the ground freezes up. In the spring, if no grass is available, they feed freely on grain. They rarely come above the surface of the sod, but pull entire plants into the ground and there feed on them at their leisure. These cutworms mature before the end of May.

Special control measures.

Since the greatest damage from these cutworms appears always to be associated with the presence of grass during the egg laying period, care should be taken to cover sod completely when it is being broken. The same precaution should be taken when cultivating summerfallow in which much grass is present.

Bart is useless for these cutworms, since they come to the surface even less than do pale western cutworms.

WHEAT-HEAD ARMYWORM (*Proteoterasia abditus*).**Distribution.**

Though this armyworm has a widespread distribution in southern Alberta, it has never occurred in sufficient numbers for it to become a pest of much economic importance.

Life-history and habits.

Though, in the central States, this insect passes through two generations a year there appears to be one only in Alberta. The young larvae feed on the blades of wheat, but the chief damage is caused by the full grown armyworms which climb to the heads where they hollow out nearly mature grains, leaving little more than the bran.

Control.

Up to the present time, damage to wheat has always been so slight in Alberta that no control measures have been practised

Elsewhere poisoned bait has given excellent results in killing the armyworms as they move from plant to plant on the ground.

Since the moths lay their eggs on timothy in preference to wheat, care should be taken to destroy all traces of timothy sod before wheat is seeded in a field in which this grass has been grown.

BEET WEBWORM (*Lexortega sticticalis*).



FIG. 11. Beet Webworm. A Eggs, laid on underside of lambs-quarters leaf. B. Full-grown Beet webworm (green with black marks). C. Cocoon dug from the soil. D. Cocoon opened to show pupa. E. Adult moth (pale yellowish brown.) All figures natural size.

Distribution.

Entire province. Liable to be extremely abundant in every district.

Life-history and habits.

Beet webworms are the caterpillars of small light-coloured moths which are about $\frac{3}{8}$ " long and of rather slender build. These moths occasionally fly in dense swarms along the side of roads in May and June and again in August. They lay nearly all of their eggs on lambs-quarters. From these eggs hatch green-and-black caterpillars which feed on the weeds. When too many eggs have been laid on the same plants the caterpillars devour them completely, and then move across the ground in dense armies in search of more food. Once they have chosen their line of march nothing will deter them. They will climb up houses, over the roof and down the other side, if these happen to be in their way. At this time they feed on a great variety of different plants but, generally speaking, will not touch grain. A somewhat rare exception to this occurs when a large army is passing through a field of wheat in which the heads are just exposed. Under these circumstances a few of the caterpillars will ascend the plants and eat some of the developing flowers from the wheat heads. Despite this unfortunate habit, webworms that pass through a field of wheat do far more good than harm. They destroy every weed that they encounter

When the caterpillars are full-grown, they enter the soil and there make long earth-covered cocoons of white silk. In these they transform to the moths.

As a rule there are two generations of beet webworms in a year. Migrating swarms of caterpillars may be seen towards the end of June and again in early September. Under certain climatic conditions, however, the first generation only is completed. The winter is passed in the cocoons, which may be turned up in large numbers when a field that was weedy during the previous summer is being cultivated in the spring.

Control.

No control measures are necessary when these caterpillars are found in grain fields. They are doing far more good than harm.

Fields of beets, sunflowers or flax may be protected from invasion with furrows baited with poisoned lambs-quarters (see page 42), or with cutworm bait. When they are already present in such fields spraying with Paris green will give satisfactory results provided the weather remains dry. This poison is, unfortunately, readily washed off sprayed plants with rain. In recent years it has been found that more certain results can be obtained from spraying or dusting with poisons made from pyrethrum. This poison has the advantages of killing the webworms almost as it comes into contact with their bodies and in being non-poisonous to man or livestock.

For further information see:

Strickland, E. H., and Criddle, W. "The Beet Webworm." Division of Entomology, Ottawa. Circular 14, 1932.

DIAMOND BACKED MOTH (*Plutella maculipennis*)

Distribution.

Entire province.

Life-history and habits.

Occasionally, at harvest time, heads of wheat are found to be carrying small bee-like cocoons through which can be seen a caterpillar or chrysalis. The cocoons are about the same length as a grain of wheat. These are quite harmless to the wheat. The green caterpillars of the diamond backed moth feed on mustard and a few other weeds. When they are full-grown many of them leave the plants on which they have fed and climb neighbouring stems of wheat, on the heads of which they spin their cocoons. They never feed on the wheat, and have done more good than harm by destroying some of the weeds.

MAGGOTS OF FLIES

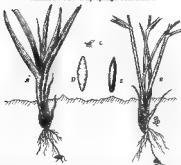
HESSIAN FLY (*Phytomyza destructor*).

FIG. 12—Hessian fly. A, Wheat seedling attacked by fly, showing two "flax-seeds" near base, B, Healthy wheat seedling, about 6" high, in same stage of development as A, C, Hessian fly, about life-sized, D, Full-grown maggot, and E, "Flax-seed" (much enlarged)

Distribution.

In 1916 this European wheat pest, which many years earlier had been accidentally imported into the eastern States, spread from the south into the fall-wheat growing area in the extreme S.W. corner of Alberta. At about this time the farmers in that part of the province gave up growing fall wheat and the hessian fly disappeared.

In 1939, it suddenly reappeared over a large area in central Alberta and, by 1940, it was known to extend from Lloydminster and Wainwright, on the east, to as far west as Tofield and Camrose. During the early summer of this year, an examination of a large number of fields showed that, in several of those which had been seeded early in May, between 15% and 25% of the plants were infested with the larvae of the first generation. No further observations were made throughout the war period and there are no records that this insect attracted the attention of farmers. Between 1944 and 1947, a careful examination of fields revealed that the

infestation had not been entirely killed out even by the 58° below zero air temperature of the winter of 1942-43 to which much of this territory was subjected. In 1943, several farmers reported moderate damage by second generation larvae. For this reason, everyone should be acquainted with the type of damage it causes and the control measures which are recommended for it.

Life-history and habits.

There are two generations of the hessian fly each year. The maggots of both attack wheat freely in Alberta. It is stated that, in Manitoba, they also attack barley and rye. Oats are practically immune but several species of grass may be infested.

The winter is passed in the pupal ("flax seed") stage. In so far as we know, the majority of them are to be found in the straw-piles of the current year's crop. Others, probably, are present in or on the ground in which the infested wheat was grown.

During May, the minute gnat like flies escape from the pupae and lay their eggs on the blades of wheat seedlings. From these eggs emerge very small, oval maggots which have a pearly lustre. These work their way below ground between the blades on which the eggs were laid, to the bulb of the seedling. Here they feed on the more central shoot which withers and dies. The outer leaves remain stunted, become somewhat broader than usual, and assume a bluish tinge. In all cases which we observed, the plants were able to produce stools, which soon replaced the first shoot, though this failed to make any further growth. The damage caused by this first generation of the flies did not, therefore, appear to be very severe.

By about the middle of June, the grubs are mature and they turn into pupae which are small, reddish, and hard. They are of about the same colour and size as a flax seed. Although the resemblance is not very great, these pupae are universally termed flax seeds. All of the flax seeds which we obtained during May and June in 1949 produced a second generation of flies during July. It is stated that, in Manitoba, many of them fail to do so until the following May and that they therefore, remain in the infested stubble throughout the winter.

The flies which emerge in July, again lay their eggs on the blades of the heading wheat. The blades usually selected are those arising from the second or third node above ground level. The second generation grubs from these eggs travel down within the leaf sheath to the node. Here they feed on the stem which becomes so weakened at this point that it falls over before the grain is ripe. By harvest-time, practically every infested stem has fallen over and is

lodged against neighbouring plants. An examination of the point at which the straw falls over will, almost invariably, reveal a "flax-seed" within the leaf-sheath. Here it will remain until the grain is threshed.

Damage.

In the fall of 1939, when several fields were observed in which about 15% of the stems were infested, the grain from a similar number of affected and of unaffected heads was threshed out separately. That from the former had a greenish tinge which did not disappear in storage. It was estimated that it might grade No. 3, when the unaffected wheat graded No. 2. Since however, the infestation of the field was only 15% it was not considered that the grade for the entire field had been appreciably lowered. The weight of the two samples was almost identical. It is, of course, possible that the flies had infested only the best developed stems and that the loss was greater than it appeared to be, but field observations failed to indicate that this was so.

As stated above the straws bend over at the second or third node from the base. This is sufficiently high for all of them to be cut by a binder which is set to cut about 4" from the ground. In several fields examined no missed heads could be found after the binder had passed. The loss to the farmers appears, therefore, to have been negligible from the activities of both generations of the hexam fly.

It would be unwise, however, to assume that this would always be the case. Poor growing conditions in the spring might result in the death of many seedlings as a result of attack by the first generation and, in a severely affected field or in one with a thin stand, many heads of stems infested by the second generation might fall right to the ground or at least to below the cutting bar of the binder. In either case they would be a total loss.

Control measures.

- 1 Since practically all of the "flax-seeds" from the second generation are picked up by the binder, all of them will find their way to the straw pile and the screenings. All which are fed to stock will be destroyed.

- 2 Stock can be allowed to feed around the straw piles during the winter but any straw which is left should be burned before the beginning of May.

- 3 Straw from infested fields should not be used for bedding-down stock.

- 4 Burning-over stubble immediately after harvest should destroy any flax-seeds which are on the surface of the ground, but

this will not affect those of the first generation which may still be in the stubble. It is probably better to cut close to the ground in order to pick up all heads from infested straws even though this reduces the possibility of getting a good burn.

5. If you intend to plough infested wheat stubble before reseedling to any crop in the following spring, do so before the end of April in order to bury any flax-seeds which may be on the surface or in the stubble. Make sure that you bury all trash.

Note—In the districts in which hessian fly has occurred in Alberta the wheat stem sawfly also is a source of serious loss in certain years. Unless the hessian fly becomes a more serious menace than it has been up to the present it is suggested that shallow fall cultivation of wheat stubble be maintained in order to reduce the sawfly and that any deep ploughing be deferred until the spring. Such spring ploughing should be followed, when possible, with a packer.

6. Cultivate all fallow following wheat frequently until the end of June in order to destroy all volunteer growth and, with it, any first generation hessian fly grubs which it may contain.

7. In the United States, where the second generation of the hessian fly is frequently the most destructive pest from which fall wheat suffers, resistant varieties are grown and seeding is delayed until after the flies of this generation have finished laying their eggs. It would appear that damage from the first generation could be avoided in Alberta by taking similar precautions. In 1940, up to 25% damage was observed in all fields which had been seeded before May 10th, while there appeared to be none in any which were seeded after May 17th. The safe date would undoubtedly vary from year to year, and 1940 was, admittedly, a late season.

WHEAT STEM MAGGOT (*Meromyza americana*).

Distribution.

Uncommon in Alberta, but liable to be scatteringly present anywhere in the province.

Life-history and habits.

The maggots are the larvae of a very small green and black fly which lays its eggs on the blades in June. The young maggots, on hatching, work their way inside the leaf-sheath to the top node. Here they feed on the flowering stem and entirely sever it from the plant. By the end of July the head dies and turns white. Other grains and grasses are attacked and are similarly affected.

Control.

There is no practical control measure for wheat stem maggots in the small numbers in which they occur in Alberta.

Trap crops and poisoned bait for the flies have been employed elsewhere where the insect is more abundant.

WHEAT SHOOT MINERS (*Hylemyia cerealis*, etc.).**Distribution.**

As yet these insects have been recorded as attacking wheat severely only in the southern half of the province. Light infestations are, however, widespread.

Life-history and habits.

The flies, which much resemble house-flies, are active shortly after the grain is above ground in the spring. They lay their eggs on the young plants. Their maggots are very similar to root-maggots of cabbages. They burrow into the plant and feed chiefly on the central shoot. When the plants are very young they may be killed outright, but if more than about three blades have been formed it is probable that only the central shoot will wilt, while the older blades continue to grow though they may assume a bluish tint.

In a badly attacked field it may appear, during the latter part of May that the crop is entirely ruined. At about the time that the owner decides to plough it in, it is probable that a marked improvement will be noticed. This is due to the fact that the maggots have matured and have left the plants in order to pupate in the soil.

Control.

There are few records of wheat fields in Alberta being badly infested with this insect. When its presence is suspected a few plants should be pulled up and torn open in order to expose any maggots which may be present near their base. If these are "wedge" shaped, i.e., much narrower at the front end than at the other, they are one of the wheat shoot miners. Having thus determined the cause of the trouble, the farmer should be in no hurry to take any action. Provided there is sufficient rainfall, most of the attacked plants will recover and their development will be found to have been retarded very little despite their unhealthy appearance earlier in the season.

Deep fall or spring ploughing reduces the number of flies which will emerge during the spring.

SEED-CORN MAGGOT (*Hylemyia stilpnus*).**Distribution.**

Entire province. Uncommon in grain fields.

Life-history and habits.

The winter is passed in the pupal stage in the soil. At about seeding-time flies which closely resemble houseflies, emerge and lay their eggs on the ground over shallowly seeded wheat. These give rise to white legless maggots which are similar to the root maggots of cabbages. They burrow down to the sprouting seed and suck out the contents, thus preventing any further development.

Control.

Seed-corn maggots have nowhere proved to be of sufficient importance in wheat fields to warrant the employment of control measures. A few of them may, however, occasionally be found in wheat that has been seeded on stubble.

LEATHER JACKETS (*Tipula* spp., etc.).**Distribution.**

Entire province. Abundant only in damp locations and in irrigated fields.

Life-history and habits.

Leather jackets are the larvae of the extremely long-legged flies known as crane-flies, or daddy long-legs. They somewhat resemble dull brown cutworms with no legs or heads.

Although they feed on the roots of grains and grasses, they are never present in sufficient numbers to cause appreciable damage to grain.

MARCH FLIES (*Bibio albipennis*).**Distribution.**

Entire province. Abundant only where much decaying vegetation is present, such as in comparatively new breaking or in heavily manured fields.

Life-history and habits.

Occasionally, when seed-beds are being prepared in the spring, the ground is found to be swarming with dull brown grubs, about $\frac{1}{4}$ " long which on close examination are found to be covered with fleshy spurs somewhat resembling rose thorns. They are full-grown at this season, and very soon will pupate beneath the surface of the soil. Later they mature into flies which somewhat resemble large, clumsy mosquitoes.

Since these grubs feed only on decaying vegetation, they are quite harmless to grain.

WHEAT STEM SAWFLY

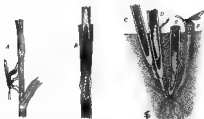
WHEAT STEM SAWFLY (*Cephus cinctus*).

FIG. 12.—Wheat stem sawfly.—A Sawfly laying an egg in a young wheat plant. B Grub inside straw. It has just eaten through a solid node. Note the "sawdust" that partly fills the straw. C An uninfested straw. D Grub cutting infested straw at harvest time. E Grub which has plugged the straw stub with "sawdust" and has made a cocoon within which to pass the winter. F Sawfly escaping from stub in the spring, after pushing out the plug of "sawdust." All figures natural size.

Distribution.

The present distribution of this pest is in the southern half of Alberta to about as far north as Camrose in the west and to Lloydminster in the east. It is improbable that it will spread much farther northward, but it is likely that it will gradually extend its territory well into the foothills to the west. In this connection it should be noted that the sawfly as a grass-inhabiting insect is found all over Alberta, including the Peace River district. Elsewhere than in the south and east of the province, however, it attacks grasses only, and there is little likelihood of it becoming a pest of wheat.

Life-history and habits.**Sawflies.**

The adult sawfly is a small black and yellow wasp-like insect with dark wings. It is about $1\frac{1}{3}$ " long. Sawflies first appear on the wing late in May, and they continue to fly until the middle of July. They are very inactive, and spend most of their time resting on stems of grain or grass. When they do fly, they remain near the

ground and travel only a short distance before resettling. In so far as is known, they require no food other than water.

Egg-laying

The majority of eggs are laid in June, though in some years they continue to be laid until the middle of July.

The sawfly settles head-downward on the young wheat plants and with a pair of saws at the end of her body, she cuts a slit through the leaf-sheath into the flowering stem somewhere below the developing head. Through this slit she forces a small white egg. A number of sawflies will lay eggs in the same stem. This is an important thing to remember in connection with control. One of the grubs which hatches from these eggs will eventually kill all the others that are present. From this it is evident that the more we can crowd the sawflies at egg laying time, the greater will be the mortality among the grubs.

Grubs

The small grubs which hatch from the eggs burrow downwards within the hollow straw and eat their way through the solid nodes in so doing. The straw through which they have passed, is partly filled with a sawdust like material. The head meanwhile develops normally. Though there is a reduction in the yield of attacked stems this is not very serious. By the time the heads begin to ripen, the grubs are below ground inside the straw. The grub turns around, so that its head is uppermost and cuts off the straw at a point that is usually about 1' above the ground. After plugging the open end of the stub with "sawdust," the grub constructs a papery cocoon in which it remains more or less inactive until the following spring, when it pupates and later escapes as a sawfly by pushing out the plug. In some circumstances the sawfly may not emerge until the following year.

Plants that are attacked.

Originally sawflies laid their eggs only in native grasses. Now, however, they lay them as readily in all grain crops. The grubs can mature successfully only in spring wheat, in spring rye and in a variety of native and cultivated grasses. Although eggs are laid freely in oats the grubs that hatch from them die almost immediately and do no damage to the crop. They live somewhat longer in barley, but very rarely mature.

Effect of climate on sawfly abundance

Generally speaking, moderately dry seasons are favourable to sawfly abundance, as well as resulting in increased damage. Excessive moisture, or extreme drought, in June and July reduces

their numbers, but once they have appeared in a district they will always be present in sufficient numbers to cause severe losses when climatic conditions are favourable to them.

Control measures.

Cultural methods for destroying sawflies

Since every sawfly that has bred in wheat passes the winter in the stubble, it has been considered that if, in the fall, the infested stubble be ploughed into the ground with a mould board plough, few of the sawflies will be able to escape in the spring. Our own experiments have proved that fall ploughing if anything increases winter survival, although it does retard spring development. This delays egg-laying, and for this reason may be somewhat beneficial. Spring ploughing has very little effect on the sawflies.

In those areas in which snowfall is light, shallow fall cultivation gives better results than does deep ploughing. The object of such cultivation is to drag as many of the infested stubs to the surface as possible and to leave them exposed throughout the winter. Only in those stubs that are entirely exposed will the grubs perish. The cultivator should therefore be set to work no more deeply than is necessary to drag them out.

Stubble burning will not destroy the grubs. They are too far below ground to be affected by the heat even when a stubble burner is employed.

Rotation of crops and trap cropping.

Never seed wheat in a field in which sawflies damaged the crop in the previous year. Grow wheat only after clean summerfallow, or after some immune crop such as oats, barley or flax that was free from volunteer wheat.

All clean wheat fields should be protected from invasion by egg-laying sawflies with a trap crop seeded around their edge.

In May and June when recently emerged sawflies are seeking suitable stems for egg-laying, they fly near the ground till they reach a growth of grain or grass that is about 6" or more in height. Having found this they move very little but remain in it till they have laid their eggs. If they enter the edge of a well-advanced wheat field they usually lay nearly all their eggs within the first two rods from the edge. If, however, the field be backward they may scatter throughout it before the plants are of a sufficient height to attract them for egg-laying. Thus the whole field is liable to be affected, with a concentration on the earliest developing knolls. Farmers cannot avoid trouble, with any certainty, by seeding either earlier or later than their neighbours.

A trap-crop grown around the edges of the field is the most certain method for reducing infestation. This consists of a more vigorous growth of a suitable grain or grass than that in the field to be protected.

Brome grass, seeded along the headlands and fence-rows, is the most effective permanent trap-crop that can be grown. It is very attractive to the sawflies for egg laying, and it makes the necessary vigorous growth in the spring. When sawflies are abundant they lay many eggs on almost every stem of this grass. Many die a natural death in brome, as they do in barley. Many more are killed by other insects, their parasites. The heavily infested trap-crop of brome will not, therefore, breed many sawflies but it probably will produce a large number of parasites. Unfortunately, these parasites which attack sawfly grubs in brome are far less successful in attacking those that inhabit wheat. Mr. Seaman finds, however, that if the grass be cut for hay at about the middle of July, parasitism will increase in nearby wheat. This is due to the fact that the parasites have two generations a year, and that the second generation are seeking sawfly grubs in which to lay their eggs at this time.

The greatest advantage from seeding brome along the fence-rows is that, once it is established, the wheat-stem sawfly will be permanently held to comparatively harmless numbers in all fields so protected provided an appropriate rotation is followed. In addition the brome will yield valuable fodder in this normally useless land, and it crowds out many weeds which otherwise would grow later.

Oats or wheat can be employed for temporary trap-crops. Each has its advantages under different conditions. In either case the trap-crop consists of a single drill-width of grain seeded as early as possible around the edges of the field to be protected. It is essential that it be well in advance of the wheat in the field when the sawflies are flying at the end of May and in June, and it will prove more effective if a drill-width of bare ground can be left between it and the crop.

The chief advantage of employing oats is that all sawfly grubs from eggs laid in it perish. As a result there is no necessity to cut it before it is ripe.

Wheat has the advantage that its flowering stems lengthen more rapidly, within the leaf-sheaths, than do those of oats. It is only after these stems have reached a certain length that the trap will retain the sawflies for egg-laying. In a season in which early growth is unusually slow an oats trap is liable to prove largely

ineffective. For this reason, wheat is a more dependable trap-crop than oats.

The main disadvantage of wheat as a trap-crop is that unless a resistant variety is used, it must be cut for green feed by the middle of July in order to destroy the sawflies that it harbours.

Control measures adapted to strip farming

In fields in which it has been found necessary to adopt strip farming methods for reducing the danger of soil drifting, the problem of sawfly control is more difficult than it is elsewhere. We would stress the value of protecting each field with a brome grass trap-crop seeded around it.

If light sawfly damage is observed at harvest time, all of the stubble strips should be shallowly cultivated as soon as possible. This should destroy at least two-thirds of the sawflies which would, otherwise have hibernated here. In the following spring, seed as early as is possible in order to keep the majority of the egg-laying sawflies in the outer rows of the wheat.

Should the sawflies become a serious pest in such a field the most satisfactory treatment would be to replace the wheat in it with oats, barley or fall rye for one year during which every effort should be made to assure that the entire field is free from a volunteer growth of wheat in which the sawflies could continue to breed.

Cutting Wheat on the "Green Side"

Sawfly grubs sever the straw only when the latter is beginning to dry out at the base. At this time, whatever the rate of maturity, the grain is beginning to ripen. It is possible to harvest a uniformly maturing field just ahead of the appearance of sawfly damage without causing serious shrinkage. In this manner most of the damage can be avoided. Experience alone will inform the farmer of the first day on which he can begin to cut. He will, however, have only about four or five days during which he can harvest in safety before the grubs begin to cut down infested straws. It is necessary, therefore, to concentrate during this period on harvesting the worst infested fields.

At about two weeks before harvest gather at least 500 straws selected from different parts of the field. Split each one open. Every straw that contains a sawfly grub will be partly filled with a sawdust-like material. If 70% of the straws collected in a certain part of a field are infested, approximately 70% of the crop will be lying on the ground if it is not harvested till it is dead ripe. In another part of the field, or in another field, 2% only of the straws

may contain this dust. Obviously, there is no urgent necessity to cut this area early, but every effort should be made to harvest as much as is possible of the first before damage shows up.

Implement manufacturers are now producing teeth to be fitted to combines which will gather many of the fallen straws. Their use greatly reduces losses.

Growing resistant varieties of wheat

Several varieties of wheat, which are resistant to the attacks of sawflies as well as to rust, have been developed in recent years. While the quality of these solid stemmed wheats such as Rescue is not considered to be the equal of several other varieties their employment where satisfactory other control measures have not been adopted will greatly reduce losses from sawflies. They are also useful as trap-crops since there is no need to cut them green.

For further information see:

Strickland, E. H., "Methods of Reducing Wheat Stem Sawfly Damage," Department of Agriculture, Edmonton, 1939.

Forstad, C. W., "Control of Wheat Stem Sawfly in the Prairie Provinces," Special Pamphlet No. 19, Division of Entomology, Ottawa, 1941.

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Debra Deane

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